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The New "Proceedings"

The receipt of the latest issue of the "Proceedings"* of the Institute of British Foundrymen caused us to wonder what reception the book is accorded by the different members. We confess that the first thing we look for is—due to vanity—our own name, and follow this by a criticism of any contributions we have made, but ours is perhaps an exceptional case. Others may examine its physical aspect from the angle of their own technical library, but so far as this is concerned, general approbation has been given to its new format. The correct appreciation of the book should, however, lie in its value as a work of reference. An officer of the American Foundrymen's Association very neatly stressed this point in some publicity matter he prepared for selling excess stocks of their "Proceedings." His method was to prepare a series of questions—popularly known in the daily Press as a "quiz"—all of which related to matters likely to exercise the minds of a modern plant executive. The answers were given as page references to past volumes of the "Proceedings." Though this new volume of the "Proceedings" is somewhat attenuated owing to war conditions, and runs to only 268 pages, its size is at least equal to what members received but a few years ago, when it appeared in the single column make-up. In technical value it enhances those earlier volumes, because of the realistic attitude now assumed by writers on foundry developments. With the passage of time, foundry research facilities have increased beyond recognition, and simultaneously with this the executives have demanded and obtained increased staff of an intelligent type to help them to record the technical as well as the financial data necessary for the proper conduct of their duties. An analysis of the contents of this new volume shows that, of the 24 Papers included, 17 were devoted to various aspects of the manufacture of grey iron castings, three or four to non-ferrous alloys, two to sands and one each to malleable and steel. Examining first those devoted to cast iron, it will be revealed that the authors are mainly attached to those sections of the industry which have been called upon to make exceptional efforts to supply war needs, whilst the contributions from the light castings side consist of one Paper on enamelling by Mr. Donaldson. Yet it is this group of foundries which has, generally speaking, not been overburdened with work since the war began. Moreover, we are prepared to hear that, when hostilities cease, the personnel of this particular branch will be too busy to prepare Papers! The members of both the machine tool and engine building sections admit that they have benefited from the policy of the free exchange of technical information, and they will endorse our plea that the light castings trade would be helping themselves considerably by a greater participation in technical activities. In the light castings trade there are far too many of the directors who still rely entirely on the moulder to produce good castings—whilst ignoring the wealth of technology that requires systematic development in their own works. What is more important, however, is that the results of such application—and in quite a few cases application has been made—should be published for the benefit of the trade. For example, mechanisation has been introduced into a number of light castings foundries; yet neither by technical Papers nor by publicity has the world been told whether the articles made by such plants are better, worse, or exactly the same as the castings when made by hand labour. In most industries, when large sums have been spent on new plant, the publicity department usually manages to get a new angle with the object of showing how quality has been enhanced. Those thoughts arose from perusing the new issue of the "Proceedings," for we realised that some recipients would take the wrong viewpoint, by thinking the information published was not quite in their line, instead of taking concrete steps to ensure that the type of information they would most value will figure in future issues. Work of the type published by Mr. Longden in his Paper "Some Observations on Contraction in Grey Iron," if repeated by makers of rain-water castings, would be of the greatest practical value.

The three Papers on non-ferrous practice by Hudson, Laing and Hopwood, as well as a portion of the one by Brisbois and Cartwright, together make a serious contribution to the solution of problems at present exercising the minds of many foundrymen. The new "Proceedings" has well maintained its reputation as being the finest and most authoritative textbook available to the foundry industry.

* Volume XXXIII 1939-40.

Pitting of Stainless Steels

An investigation of the formation of pits in stainless steels is described by Uhlig, in "Metals Technology." The conclusions he reaches as a result of his work may be summarised as follow:

Pit corrosion of stainless steels appears to be caused by breakdown of passivity at localised areas through electrolytic action. Potential differences on the surface give rise to corrosion products at the focus of corrosion. These potential differences may be established, for example, by certain kinds of inclusions or segregations in the alloy or by differences in oxygen or oxidising concentration of the electrolyte in contact (contact corrosion). The corrosion products, largely ferrous salts, acidic in character (*p*H 1.4 to 2.0), have the property of destroying passivity and establishing a corrosion cell between passive and active metal, the operating potential difference being about 0.5 volt. Current then flows in greater magnitude with accelerated formation of corrosion products. If the corrosion products can accumulate, as in a pore or fissure of the metal surface, the high potential difference of the cell is maintained and pitting results. The rate of corrosion depends on the efficiency of depolarisation at the cathodic areas surrounding the anodes or pits. Because of the non-corrosive character of metal outside the pit, further protected by corrosion currents that limit access of negative ions to cathodic metal, the incipient corroded area is limited in surface dimensions and tends to grow deep rather than broad.

Two factors appear essential for the rapid pitting of 18:8 stainless steel; the one being a sufficient concentration of chloride ion, and the other a sufficient oxidising potential of the corroding solution. If the molal oxidation-reduction potential of the corroding solution is more positive than approximately − 0.15 volt, 18:8 loses passivity and tends to corrode by general solution rather than by pitting. Only in solutions that normally maintain passivity, and in which 18:8 is therefore corrosion-resistant in the usual sense, is pitting apt to occur. For oxygen dissolved in salt solutions, the molal potential is − 0.40 to − 1.23 volt, hence these solutions as observed maintain passivity and in these solutions pitting can occur.

The observation that growth of pits is in the direction of gravity, forming "streamers," is explained by the action of heavy corrosion products of the pit in leaking out to contact new areas of passive alloy. Wherever such contact is made, passivity is destroyed and new corrosion cells are established.

If corrosion products do not accumulate, oxygen or oxidising solution diffusing to the attacked area will tend to reform the passive state and prevent pit growth. Hence pitting is less in well aerated and stirred solutions. 18:8 may be activated by acids or acid chlorides to such a degree that passivity is not regained by contact with oxygen in salt solutions. In this case corrosion already initiated is not inhibited by aeration. The alloy is passivated, however, if dried in air or washed with distilled water containing dissolved oxygen.

All these statements of theory and observation are based on laboratory experiments and on service tests in sea water. The "stream-beaker" experiments in which synthetic corrosion products flowed in a stream over metal immersed in a corrodent demonstrated the action of corrosion products in the mechanism of the elongated pit, the importance of the passive-active surface cell in the mechanism of pitting and the effect of chloride-ion concentration in the stream in increasing the rate of

(*Continued at foot of next column.*)

(*Continued from previous column.*)

pitting. The artificial pit in which 18:8 alloy was made anode in a sodium chloride electrolytic cell supplied information on the nature of the corrosion products and the mechanism of corrosion inside the pit. Electro-chemical potential measurements indicated that corrosion products break down passivity, as does lack of oxygen in a salt solution in which 18:8 is immersed. The active to passive state transformation was found dependent not only on oxygen or oxidant concentration, but also on sodium chloride concentration of the corrodent.

An Industrial Museum for Birmingham?

A DUTY TO POSTERITY

Mr. C. H. H. Franklin, B.Sc., in his Presidential Address to the Birmingham Metallurgical Society, made a plea for a change in outlook by those responsible for the museum facilities in Birmingham.

"Surely so great an industrial city," he said, "can afford to display, not merely examples of art and curios from distant parts, but relics of its own industrial growth, and models which show what has been and can be done. London has its South Kensington; Liverpool displays its shipping models; Sydney and Melbourne own technical displays which show what should be done."

Describing shortly the Sydney Technological Museum, Mr. Franklin said that its main building was carried on three floors, about the same total area as the Birmingham City Museum. It was devoted mainly to the display of State products, their growth and manufacture, including in many cases evolution of method; timbers, minerals, metals, methods of mining and extraction, past and present, were all laid out. Nearby, in a special building, were housed a Watt beam engine; the first Australian locomotive; early oil and gas engines and other relics of local engineering growth. It was a living museum, used both by the public and by those receiving State technical instruction.

Amongst items which should be on permanent display were the early "smithes" of "Bermingham." but, unfortunately, they seem lost beyond recall. However, Dud Dudley, Hall, Siemens, Muntz, Turner, Dick, Elkington, Parkes and others can be recalled, and the processes they evolved and relics of their work could, and should, be found and kept.

When peace returns and wise building is the order of the day, surely it will be a civic duty to record for posterity the heritage of craft possessed, the way life has grown to what it is, and with display of past, to provide models which will explain in the simplest way the background of principle on which both craft and growth depend.

What could be a better work for the skilled craftsmen of the future than the modelling of a Ward or Archdale lathe, a Tangye engine, or a Belliss set, as they are true records of Birmingham's life and growth? There are dotted about Birmingham many skilled amateurs, whose delight it is to make in their leisure time, with their own limited facilities, models, mechanisms, and engines which are both well finished and efficient. Well might the city assist the best of these in their endeavours and welcome their efforts towards embellishing its records. Often the amateur has difficulty in obtaining materials or castings really to suit his wants. Here the city authority should be able and ready to assist proved skill, likewise local firms be willing to assist competence with metals or appropriate help.

Random Shots

The "right spirit" was amply demonstrated recently by a little girl who, living not many miles away from London, went up to town for the first time since the blitz. Whether or not she had expected to see everywhere in ruins will probably never be known, but what she did see evidently impressed her very much, for when she got home she at once sat down and wrote a letter to each of her six aunts who live in the provinces. This is what she wrote:—

"Dear Auntie,—I have been up to London to-day for the first time since the blitz, and I want to tell you, in case you don't know, that it is not nearly so bad as people make out."

* * *

A story is told of an ex-moulder who is now a member of the bomb disposal squad. He was sent to the heart of the country to attend to an unexploded bomb which had fallen in a field near to a farmhouse. He was discussing with his mate as to the best method of approach (and seemed more anxious than the other to get to it) when some very vigorous bulls strolled into the field where the bomb was lying. "I say, mate," said he after spying the intruders, "I'll tell you what. You go and get the farmer to shift those bally bulls and then we'll hop along and settle the old bomb."

* * *

Many people are feverishly reading up how to keep bees. Is it their earnest desire to augment the jam ration, or have they got an eye to providing themselves with an extra weapon of defence in case of invasion?

* * *

Optimism! A certain rural council in the South of England has voted a sum of money in its annual budget for the introduction of street lighting should the war be finished before the winter comes.

* * *

New Caledonia, having prohibited the export of chrome and nickel ores to Japan, is seeking fresh outlets in America and the British Empire. Why doesn't someone tell them of the existence of the Caledonian Market, ready made for them in London?

* * *

This week's quiz:—

(*a*) What is the meaning of the following initials: I.B.F.; B.I.F.; F.B.I.; and F.I.B.?

(*b*) Cunningham's Comet is: The name of a Derby winner; an object of interest to astronomers; the lucky star of the Mediterranean Fleet; or an old provincial newspaper.

(*c*) To what English family does the Nazi-controlled Belgium find itself liable for the payment of a perpetual pension?

(*d*) The Dodecanese are: North African natives; extinct birds; a group of islands in the Ægean Sea; or rheumatic-ridden joints.

(*e*) Bimetallism is: An alloy of two metals: a system of currency; or a eutectic.

(*f*) What is a pseudo-martensitic structure?

Answers to last week's quiz:—

(*a*) Physical characteristic.

(*b*) Transitory nuclei in molten metal.

(*c*) Process of surface welding.

* * *

This week's best crossword clue comes from the "Sunday Times."

Clue—Arm an elderly man for a battle.

Answer—Armageddon.

"Marksman."

Tantung Hard-Cutting Alloy

A new general-purpose hard-cutting alloy, Tantung G, made by the Fansteel Metallurgical Corporation, North Chicago, Ill., is intended for use where higher cutting speeds than are possible with high-speed steel are desired. Composed of tungsten and tantalum carbide in a matrix of cobalt and chromium, it also machines cast iron, brass, aluminium and many other materials.

Isothermal Transformation of Austenite in Grey Cast Iron*

By CLINTON R. HILLIKER and MORRIS COHEN

It was recently shown by E. L. Bartholomew[1] that the hardness, tensile strength, impact strength, wear resistance, and surface endurance of grey cast iron may be materially enhanced by austempering or hot quenching. R. J. Cowan[2] has also reported that the wear resistance and toughness of malleable cast iron may be improved by such heat-treatment.

In this hot quenching process, the cast iron is first heated above the critical temperature in order to convert the matrix into austenite. The austenite, in turn, is supercooled to some temperature in the range of 260 deg. to 340 deg. C. by rapidly transferring the cast iron to a molten lead or salt bath operating at this temperature. A substantial part of the austenite is then allowed to transform isothermally over a period of time in the molten bath before the subsequent cooling to room temperature. The isothermal transformation product thus produced is bainite, which is quite different in both appearance and properties from the pearlitic structures formed above 540 deg. C. and the martensitic structures formed below 260 deg. C.

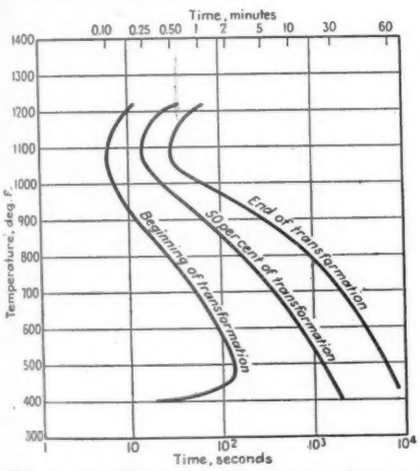
Time, minutes
0.10 0.25 0.50 1 2 5 10 30 60
Temperature, deg. F.
1400 1300 1200 1100 1000 900 800 700 600 500 400 300
Beginning of transformation
50 per cent of transformation
End of transformation
1 10 10² 10³ 10⁴
Time, seconds

FIG. 1.—ISOTHERMAL TRANSFORMATION CURVES FOR UNALLOYED CAST IRON CONTAINING T.C., 3.63; C.C., 0.71; AND Si, 1.25 PER CENT.

In view of this growing interest in the commercial application of the hot quenching process to cast iron, it seems appropriate at this time to report the results of an investigation carried out at Massachusetts Institute of Technology on the isothermal transformation of austenite in grey cast iron. Two cast irons of the following compositions (per cent.) were studied:

	Unalloyed cast iron.	Nickel cast iron.
T.C.	3.63	3.68
Gr.	2.92	2.56
C.C.	0.71	1.12
Si	1.75	1.20
Mn	0.53	0.37
S	0.10	0.11
P	0.56	0.28
Ni	—	2.03

These irons were obtained through the courtesy of E. L. Bartholomew, of the United Shoe Machinery Corporation, Beverly, Mass. The nickel cast iron was very similar to the No. 53 iron used by Mr. Bartholomew in his hot quenching experiments.[3]

Small specimens of both irons were heated to 845 deg. C. for 20 mins., and quenched into a lead or salt bath maintained at some predetermined sub-critical temperature. The progress of the isothermal transformation of the austenite was followed by the usual methods[4] of micro-examination and hardness testing on specimens which were removed from the hot quenching bath at suitable intervals and rapidly cooled to room temperature. By repeating this procedure for each of several hot quenching temperatures, the rate of isothermal transformation as a function of temperature was established for the two cast irons.

The results are shown graphically in Figs. 1 and 2. In each case, the curve representing the time in accordance with the usual practice [the time is plotted on a logarithmic scale] for the beginning of transformation is based principally on the examination of the microstructures; the curve for 50 per cent. transformation is based principally on the hardness testing; and the curve for the end of transformation is based on both types of measurement. It should be emphasised that the designation "end of transformation" applies only to the portion of the austenite which transforms progressively until no further change can be detected. Actually, residual traces of austenite may remain untransformed long after the times indicated by the end-of-transformation curve. These persistent traces of austenite are not the concern of the present Paper, and are disregarded in the following discussion.

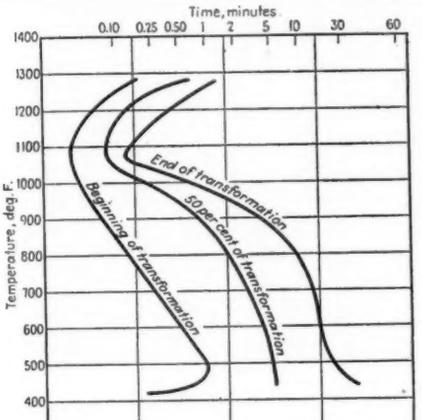
Time, minutes
0.10 0.25 0.50 1 2 5 10 30 60
Temperature, deg. F.
1400 1300 1200 1100 1000 900 800 700 600 500 400 300
End of transformation
50 per cent of transformation
Beginning of transformation
1 10 10² 10³ 10⁴
Time, seconds

FIG. 2.—ISOTHERMAL TRANSFORMATION CURVES FOR NICKEL CAST IRON CONTAINING T.C., 3.68; C.C., 1.12; Si, 1.20; AND Ni, 2.03 PER CENT.

From a comparison of Figs. 1 and 2, it is clear that the nickel addition to the cast iron results in a displacement of the transformation curves toward longer times. For example, at a temperature of 565 deg. C., which corresponds to the nose of the curves, the austenite transformation in the unalloyed iron begins in 2 secs. and is 50 per cent. complete in 5 secs., while in the nickel iron the transformation begins in 6 secs. and is 50 per cent. complete in 14 secs. This means that heavier sections can be successfully hot-quenched if the cast iron is alloyed with nickel. Undoubtedly, other alloying elements could also be used for this purpose.

The hardness values of the specimens at the end of transformation are plotted in Fig. 3 as a function of the transformation temperature. The curves for the two irons are similar in trend to the curve already published by Murphy, Wood and D'Amico.[4] It is evident that the hardness does not increase progressively as the transformation temperature is lowered. The products formed in the range of 510 deg. to 455 deg. C. are slightly, but noticeably, softer than those formed at somewhat higher or lower temperatures. E. S. Davenport[5] has demonstrated analogous irregularities in S.A.E. steels.

For the most part, the microstructures of the isothermal transformation products are the same for the two cast irons, and resemble those found in hot quenched alloy steels. At temperatures above the nose of the transformation curves, the isothermal product is pearlite, with the lamellæ becoming finer as the transformation temperature is lowered. Fig. 4B illustrates the nature of the pearlite formed at 693 deg. C. In this and the other photomicrographs, only partial transformation is shown in order to set the isothermal products off most clearly. The greyish background (actually light brown as viewed under the microscope) is the martensite which forms from the untransformed austenite during the rapid cooling from the hot quenching treatment to room temperature. For comparison, the martensitic structure produced by a direct quench from 845 deg. C. is shown in Fig. 4A. The graphite flakes and phosphide eutectic contained in some of the photomicrographs are not a part of the transformation product, and hence, for the purpose of this work, no attempt was made to photograph these constituents to best advantage.

The product formed just below the nose of the transformation curves corresponds to the "acicular ferrite" found by E. S. Davenport[5] and by H. Jolivet[6] in alloy steels. Like ferrite,

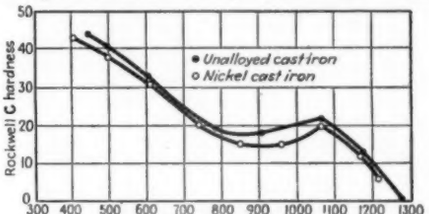
Rockwell C hardness
50 40 30 20 10 0
● Unalloyed cast iron
○ Nickel cast iron
300 400 500 600 700 800 900 1000 1100 1200 1300
Transformation temperature, deg. F.

FIG. 3.—EFFECT OF ISOTHERMAL TRANSFORMATION TEMPERATURE ON THE HARDNESS OF PLAIN AND NICKEL CAST IRONS.

this constituent in the cast irons remains clear white after etching with either nital (Fig. 4C) or boiling sodium picrate (Fig. 5A). Further confirmation of its ferritic nature was obtained by X-ray diffraction methods and by etching with potassium bitartrate, which darkens ferrite preferentially (Fig. 5B). These findings lend considerable weight to R. F. Mehl's postulation[7] that the "upper bainite" structures are nucleated by ferrite, unlike the pearlitic structures which are nucleated by cementite.

During the early stages of the ferrite formation, there is no simultaneous precipitation of carbides; instead the rejected carbon diffuses into the surrounding austenite. This movement of the carbon may be an important factor in the pronounced "slowing up" of the transformation at temperatures just below the nose of the curves. However, during the later stages of transformation, carbides precipitate at the advancing interface between the growing ferrite and the remaining austenite. These carbide regions are shown blackened by sodium picrate etching in Fig. 5A. The final product of free ferrite plus carbides readily accounts for the dip in the hardness curves of Fig. 3.

D

* Reprinted by courtesy of the Editor of "The Iron Age." The authors are Clinton R. Hilliker, Metallurgical Assistant, Bethlehem Steel Co., Lackawanna, N.Y., and Morris Cohen, Assistant Professor of Physical Metallurgy, Massachusetts Institute of Technology, respectively.

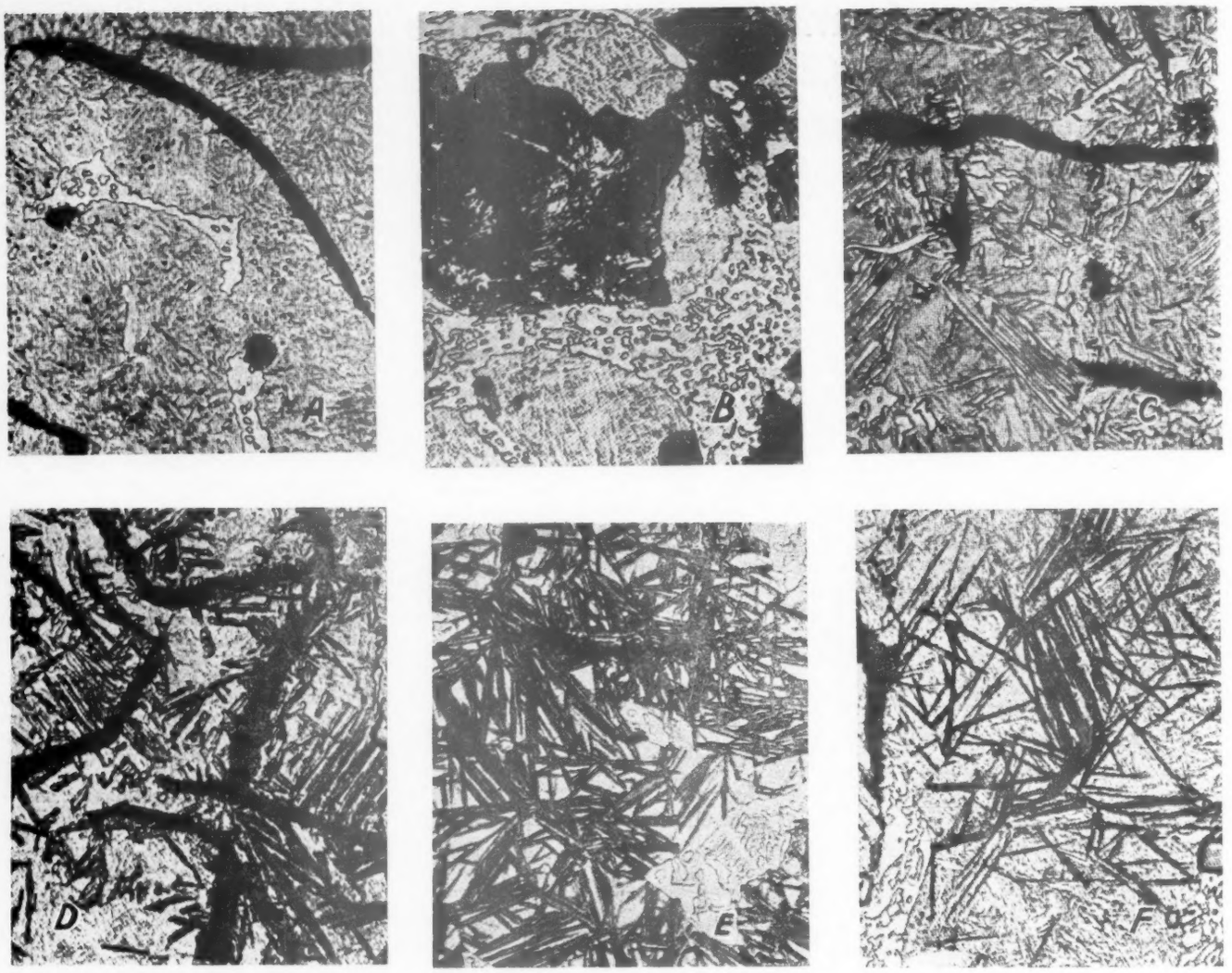

Fig. 4.—Products of Transformation in Unalloyed Cast Iron. All Etched under Identical Conditions with Nital × 1,000. A—After Direct Quench to Room Temperatures; B—After Partial Transformation at 590 deg. C.; C—After Partial Transformation at 480 deg. C.; D—After Partial Transformation at 400 deg. C.; E—After Partial Transformation at 315 deg. C.; and F—After Partial Transformation at 260 deg. C.

With the lowering of the transformation temperature from 455 to 260 deg. C., the abovementioned ferrite constituent gradually becomes darker (even with nital etching) and more angular in appearance until it finally achieves the typical deep-etching characteristics and acicular configuration of bainite, as shown in Figs. 4D, 4E and 4F. It is believed that these changes in the transformation product with decreasing temperature are associated with the decreasing ability of the carbon to diffuse into the surrounding austenite as the ferrite forms. Accordingly, at the lower transformation temperatures, larger amounts of carbon are momentarily trapped in solution in the ferrite, but precipitate almost immediately to form an extremely fine dispersion throughout the growing ferrite.

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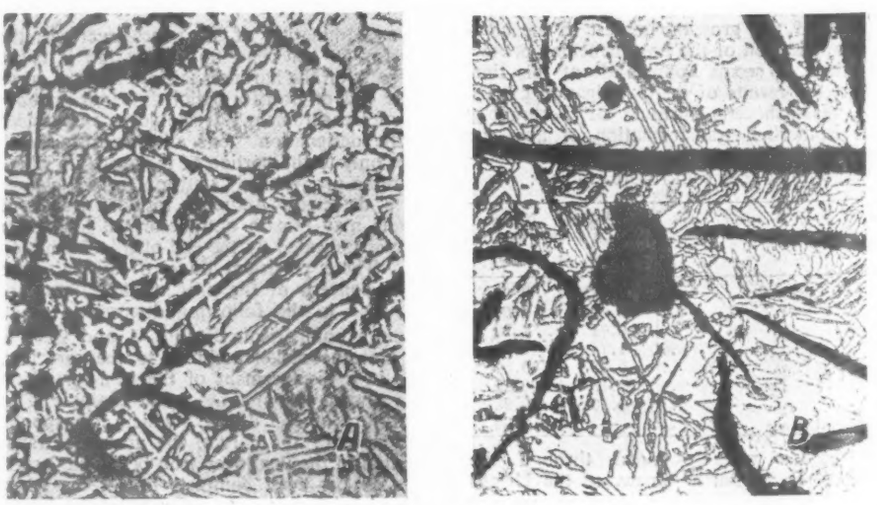


Fig. 5.—Structure after Partial Transformation at 480 deg. C. (compare with Fig. 4, C). A—Etched with Boiling Sodium Picrate × 2,000; and B—Etched with Potassium Bitartrate × 1,000.

Die Castings in Magnesium Alloy*

By HERBERT CHASE

Present indications point to the likely substitution of die castings in magnesium alloy for many parts heretofore die cast in aluminium alloy and to the use of many more magnesium die-castings for parts newly designed for the purpose. An important reason for this is the lighter weight of the magnesium alloy.

It is not in any sense to be inferred that aluminium alloy die castings are not satisfactory, for they have long since demonstrated their utility. In a large proportion of cases, however, aluminium alloy is chosen (as compared with heavier and less expensive alloys) largely or only because of its lighter weight, and since magnesium alloy is still lighter by about one-third, it has a further advantage on this score.

Strength and other physical properties of the two alloys are similar or nearly the same, but difficulties in die casting magnesium alloy, now largely overcome, have delayed its wider use. To-day, in the case of some parts, it is possible to purchase magnesium alloy die-castings at the same price per casting, as if they were produced

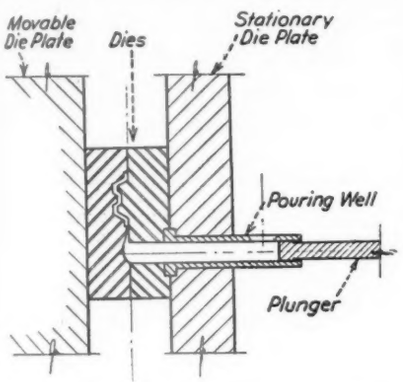


FIG. 1.—SHOWING ARRANGEMENT OF DIES AND INJECTION PLUNGER IN A "COLD CHAMBER" MACHINE FOR DIE-CASTING MAGNESIUM ALLOY. MOLTEN ALLOY IS POURED INTO THE WELL IN MEASURED AMOUNTS BY A HAND LADLE, AFTER WHICH THE PLUNGER IS IMMEDIATELY ADVANCED UNDER HEAVY HYDRAULIC PRESSURE, FORCING THE METAL INTO THE DIE CAVITY.

in aluminium alloy. In other words, the higher price per pound of magnesium is offset by the lower weight per casting.

Cold Chamber v. Gooseneck Machines

Some magnesium alloy die castings have been produced experimentally in so-called "gooseneck" machines in which air under about 400 lbs. per sq. in. pressure injects the metal into the die. Most aluminium alloy die castings are still produced on such machines, usually with good results, but with magnesium it proved difficult to protect the metal against rapid oxidation at the high temperature it was necessary to use. Much better results have been secured with so-called "cold chamber" die-casting machines which depend on an entirely separate melting pot and make use of far higher pressures. In employing such machines (some of which are used also for aluminium alloys and also for die-casting brass and other copper-base metals) the metal is kept at or slightly above its melting point in a separate melting pot and is ladled into the "cold chamber" of the machine by hand. The amount ladled at each "shot," or die filling, is slightly more than enough to fill the main die cavity, leaving a slug of excess metal which is ejected with the casting, and which makes it unnecessary to measure the charge more closely than is convenient.

A great advantage of the cold chamber machine is that, when properly proportioned, pressures of 4,000 lbs. per sq. in. or higher can be applied to the metal. This ensures a dense casting and one which has proved to have physical properties superior to those obtained in castings made in gooseneck machines. Even more important, in the case of magnesium die-castings, is that the separate metal pot makes it easier to protect the molten metal from oxidation except during the short ladling operation, when the metal is exposed to the air. It is possible, however, to avoid any detrimental effects from this short exposure and also to avoid contaminating the casting with flux or dross.

Preventing Oxidation Losses

As in other casting with magnesium alloy, it is necessary to keep the metal in the melting pot covered to minimise contact with air. This is done by providing the metal pot with a dome in which sulphur is melted and from which sulphur fumes issue. The fumes burn and introduce sulphur dioxide to form a "blanket" above the molten metal, which is thus kept from oxidising. In some cases, added protection is given by throwing a small amount of "Dow Agent No. 14" (a mixture of sulphur, boric acid and ammonium silicon fluoride) under the cover. Sulphur from the dome burns at holes around the ladle opening, and any excess fumes are drawn off through a hood which covers the dome.

Because of the high pressure applied to the metal during and immediately following its injection into the die, it is necessary to apply a heavy locking pressure to the die to prevent the halves of the die from opening slightly under the high internal pressure. This not only avoids spitting of molten metal but reduces the flash formed at the die parting. Some of the machines used employ direct hydraulic pressure for locking and others apply hydraulic pressure through a toggle mechanism for locking. In all cases, the ram for metal injection is operated hydraulically.

Apart from the precautions taken in avoiding oxidation of the molten metal, the proces is much the same as that employed in die casting aluminium and copper-base alloys in cold chamber machines. Casting temperatures are about the same as for aluminium, and the same dies can be used, except, perhaps, for slight changes in gating and venting. Casting temperatures are lower than for copper base alloys and, in consequence, there is less tendency for die surfaces to check. Die-life is correspondingly longer and dies require less redressing. Castings can be made as smooth as those in aluminium alloy. The pouring temperature ranges from about 630 to 675 deg. C., as a rule, but may have to be 700 deg. C., in some instances. Die temperatures are reported as running from 100 to 250 deg. C., with 125 deg. C. a good average, and it is said to be unnecessary to apply water cooling except for unusually high production.

Dies Used

Although carbon tool steels can be used for dies required only for short runs, much longer life results if tool steels of the type containing 5 per cent. Cr and 6 per cent. W are used. The dies are tempered at 540 to 600 deg. C. to give about 450 Brinell hardness. As dies usually become coated with a thin oxide film, other coating is said to be unnecessary. Too high a die temperature may cause excessive oxidation of die surfaces and result in rougher surfaces on castings.

It is recommended that scrap from castings be not remelted for die casting directly, but that this metal be refined by the open pot method,

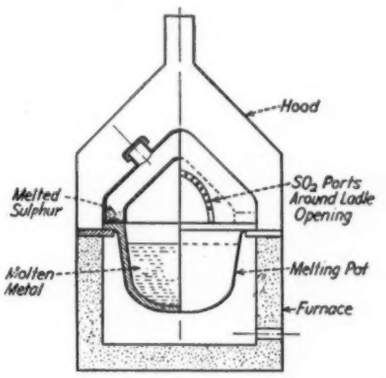


FIG. 2.—MELTING POT, SHOWING THE DOME IN WHICH SULPHUR IS MELTED AND LADLE OPENING WITH HOLES FROM WHICH SULPHUR FUMES ARE DISCHARGED AND BURN TO SO_2 WHICH PROTECTS THE MOLTEN MAGNESIUM ALLOY FROM OXIDATION.

using a large quantity of flux such as Dow No. 23A. Three-pound ingots cast from the refined metal may be remelted with virgin ingots for die casting. Casting efficiency is said to average about 95 per cent. and overall metal efficiency about 90 per cent. for medium to large size castings. Casting efficiencies may be higher if castings have wall thicknesses of $\frac{3}{32}$ in. or greater.

According to one authority (Dow Chemical

TABLE I.—*Physical Properties and Nominal Compositions of Magnesium Alloy Die Castings.*

A.S.T.M. Number	12	13	—	—
Dowmetal designation	K	R	AX	EX
Nominal composition (per cent.):				
Aluminium	10.0	9.0	8.0	6.0
Manganese	0.13	0.13	0.15	0.2
Silicon	0.5	—	0.3	0.2
Zinc	—	0.60	—	—
Magnesium	Remainder	Remainder	Remainder	Remainder
Tensile strength, tons per sq. in.	13.4	14.7	14.3	12.1
Yield strength,* tons per sq. in.	10.0	9.4	8.9	7.6
Elongation in 2 in., per cent.	1	3	3	4
Brinell hardness	62	60	60	50
Charpy impact strength, ft.-lbs.	1	2	2	3
Characteristics and uses	Highest yield strength, but being replaced by Dowmetal R.	Best die casting alloy. Good casting characteristics with high mechanical properties and good corrosion resistance.	Largely replaced by Dowmetal R.	Used where maximum toughness is desired.

* Extracted from "Metals and Alloys."

* Yield strength is defined as the stress at which the stress-strain curves deviates 0.2 per cent. from the modulus line. Physical properties are typical and are as obtained on standard A.S.T.M. die-cast specimens.

Company, to which the author is indebted for much of the information used in this article) there is little or no gain in casting at pressures above 4,000 lbs. per sq. in., and some satisfactory castings are produced at much lower pressures, but much depends on die design, casting design, alloy used and other factors. Castings have been made with walls as thin as 0.040 in. over small areas, but 0.050 in. is considered a more practical minimum, even in small castings. This commonly has to be increased as the size of the casting, and the extent of thin areas thereof are increased. Castings up to about 6 lbs. in weight are considered practical, and at least one having a length of 74 in. has been produced.

Properties of Mg Alloys

Table I containing data supplied by the Dow Chemical Company gives the physical properties and characteristics of the various magnesium alloys employed for die-castings, some of which are marketed or used by other companies under different designations. As will be seen, the alloys contain from 6 to 10 per cent. Al, all but fractional percentages of the remainder being magnesium. Surface quality and soundness of castings are said to be unaffected by the composition within the limits given, but castability is in the order listed except that the first two are about equal in this respect. Although the first three alloys listed can be solution heat-treated with increased ductility and some reduction in yield strength, a better way of increasing ductility is to decrease the aluminium content, as in the fourth alloy listed. This is because sub-surface porosity, which is not eliminated even in the relatively sound die-castings produced under high pressure, results in surface blistering if temperatures be raised in heat-treatment to 370 deg. C.

Tarnishing and Corrosion

Magnesium die-castings are subject to tarnishing and corrosion, especially when subjected to moist atmospheres and tropical temperatures, and eventually roughen as a result of the formation of oxide or hydroxide films. For this reason, and also to promote the adherence of organic and/or synthetic finishes, castings are commonly given a chrome pickle. This may be applied by the die-caster or, if the purchaser is to machine the casting, by the purchaser subsequent to machining. This pickle involves a five-second dip at 120 deg. F. in a solution containing, per gallon, 1½ lbs. of sodium dichromate and 1½ pints of concentrated nitric acid. The result is a slight etch and the formation of a film having a considerable degree of corrosion resistance, even to salt water.

Alternatives include the use of a special air-drying primer or of a baking paint on the untreated metal (both especially developed for magnesium) and intended chiefly for castings to be used indoors. In general, it is recommended that the pickle precede the application of finishes of the paint, enamel and lacquer type, and there are many such finishes suitable for use over the pickle finish.

For exposures to marine atmospheres and for other special sets of conditions, various other chemical treatments are recommended, certain of them meeting Army, Navy and Air Force specifications. Some treatments produce oxide or hydroxide coatings which, though dense, hard and adherent, can be dyed in attractive colours and have high abrasion resistance.

Until recently, the electroplating of magnesium alloys had not been considered practical, but success is reported as a result of long experimental work in this field, and nickel plating is understood to be now emerging from the laboratory into commercial applications under patent restrictions.

Although die-castings in magnesium alloy have been in moderately extensive commercial use for several years, the number of die-casters having the required experience in and equipment for their production is still quite limited. Certain hazards are involved in production. It is also considered desirable, if not essential, to segregate or isolate the production from that of other die-castings, partly to avoid the possible mixing of aluminium and magnesium scrap from castings and thereby to aid in maintaining the desired analysis without introducing the need for continuous checking of analysis. Nevertheless, the production of magnesium alloy die-castings has increased rapidly and is attaining, or seems likely to attain, proportions which may rival the production of those aluminium alloy die-castings which must be made at pressures above those attained in gooseneck (air injection) machines.

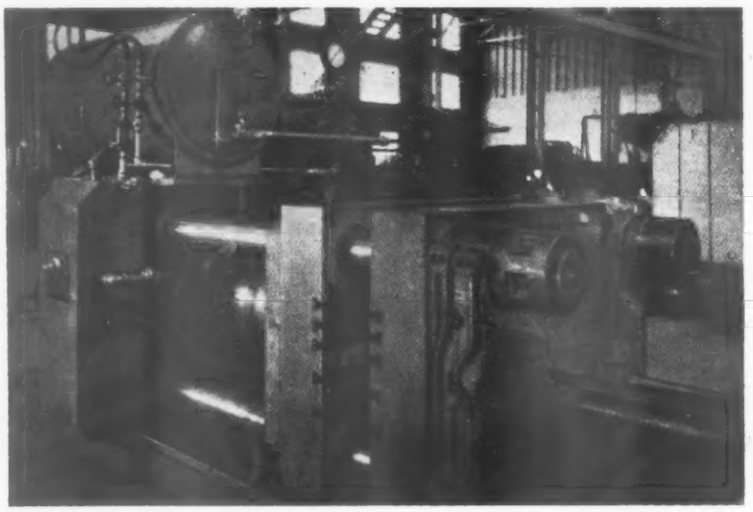


FIG. 3.—HIGH PRESSURE "COLD CHAMBER" DIE CASTING MACHINE USED FOR MAGNESIUM ALLOYS IN THE WORKS OF THE DOW CHEMICAL COMPANY.

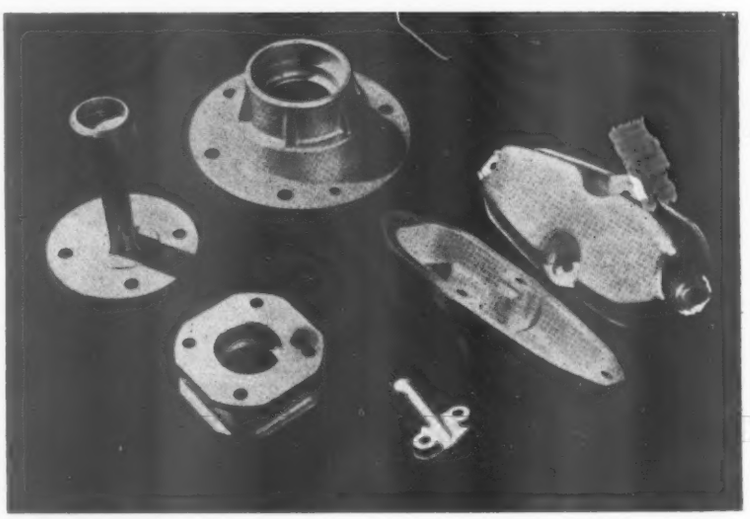


FIG. 4.—TYPICAL EXAMPLES OF MAGNESIUM ALLOY DIE CASTINGS FOR THE AIRCRAFT INDUSTRY.

Uses

Since lightest weight is the outstanding characteristic of magnesium alloy die-castings, they have naturally been chosen chiefly where lowest weight is required or is highly desirable. A great many such die-castings find their way into aircraft but, as the production of aircraft is well below that of certain other products in which magnesium alloy die-castings are used, the total number of such castings used outside of aircraft is greater than of those for aircraft.

The largest single use of die-castings in magnesium alloy is for generator and starting motor end bells on Ford cars, accounting for some 6,000 such castings a day. As these are small castings, the weight saving over aluminium (formerly used exclusively and still used for part of the total requirements) is not large. But Ford is gathering data on the large-scale use of these castings and may well find a more extensive use for them. In any event, the continued use of magnesium alloy for these parts indicates that they have given satisfactory performance.

Other uses include parts for business machines, especially portable types, including typewriters; parts for electrical appliances and portable electric tools and parts for other products in which light weight and/or low inertia forces are advantageous. Cameras, binoculars and other portable instruments as well as certain tools in which other metals would add undesirable weight, make good use of magnesium alloy die-cast parts. Indications point to further use along these and other lines, particularly where the high strength-weight ratio is of special advantage.

(*Continued on page* 249.)

Efficient Control and Disposal of Swarf and Scrap Metal

By D. F. GALLOWAY, Whit.Sc., B.Sc.

(*Continued from page* 222.)

A problem of separation which frequently arises is where the metals to be separated are fixed together. For example, sub-assemblies of small electrical fitments frequently contain brass and steel, and when such assemblies are rejected by an inspection department, they are frequently deposited in bins of assorted scrap work pieces. Such scrap is often sorted by hand, and if the scrap is left to accumulate before sorting, it soon becomes tarnished, so that the difficulty of distinguishing one metal from another is greatly increased. However, by the aid of a suitable magnet the presence of even small steel screws in large brass assemblies or of broken drills or taps in brass or aluminium work pieces are quickly detected. Such magnets may be suspended above the work-bench, stand on the bench, or be fixed flush with the bench. Where large quantities of such scrap have to be sorted the flush type of magnet is most suitable, but

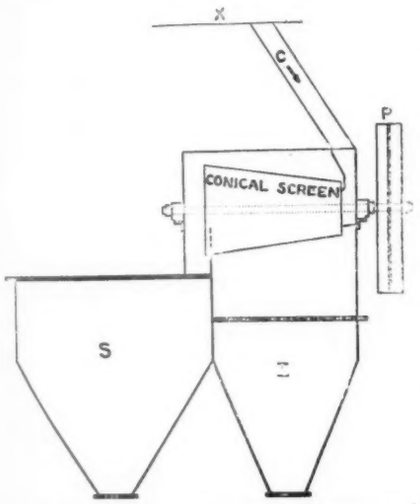


FIG. 9.—ROTATING CONICAL SCREEN SEPARATOR.

where smaller quantities are to be dealt with the initial expenditure may not be warranted, and one of the other types may be used. Such extreme care for the elimination of the smallest quantities of iron and steel from brass scrap may seem unnecessary, but the value of non-ferrous scrap increases sharply as the last few per cent. of iron and steel are extracted.

Another machine which roughly separates cast-iron and steel chips is shown in Fig. 9. It consists of a revolving conical screen into which pulverised iron and steel chips are fed through a shute C. The chips enter the narrow end of the screen, and as they roll and fall toward the large end, which is open, most of the cast iron passes through the screen into the first hopper I. The steel is not reduced to such fine grains by the pulverising process, and consequently does not pass through the screen, but is delivered out of the open end to the second hopper S. Since the sole basis of separation is the difference of chip size after pulverising, it is obvious that some steel will fall into the cast-iron hopper and *vice versa*, but in most cases the separation is sufficiently complete. The feeding point X at the top of the shute can be located at floor level, and the screen and hoppers arranged in the storey below. The screen is driven through a pulley P fixed to the end of the shaft.

It is sometimes necessary to recover metal chips from the ashes, sweepings, etc. Iron and steel can be almost completely extracted by the magnetic separators already described, but where brass, aluminium and other non-magnetic material has also to be extracted, the cinder mill shown in Fig. 10 can be used. The mixture is fed through the hopper shown on the left of the illustration into a steel grinding drum where a number of loose hard metal balls commence the process of reducing the non-metallic material to dust. The grinding is performed dry, and the dust passes through the perforated scouring drum, and is discharged through a polygonal set of sieves to the lower part of the machine. The recovered metal is then removed from the drum ready for further sorting by magnetic separator if the mixture contains magnetic and non-magnetic materials.

An effective method of separating aluminium from other metals is by flotation. The separator consists of a large tank containing a solution which has a specific gravity greater than aluminium or Duralumin or the alloy to be separated. The mixture of chips is immersed in the solution so that chips with a specific gravity less than the solution float at its surface, while others sink to the bottom of the tank, where they are caught in a perforated pan. Perforated ladles are used to take the floating aluminium chips from the surface of the solution, and to transfer them to washing vats, where the separating solution which clings to the chips is removed. The diluted solution resulting from this washing process is recovered by evaporation, which continues until the required density is regained. After removing the aluminium the pan containing the iron, steel, brass, etc., is raised from the bottom of the separating tank and transferred to the washing vat. The washed chips are passed on to one of the magnetic separators already described, and the diluted solution recovered by evaporation. This method of separation is very quick and inexpensive if the processes are properly arranged so that separation, washing and recovery of solution proceed with continuity and efficiency.

In many workshops mechanical sorting is not necessary. Where machines are engaged on the production of large quantities of components of the same material, it is usually easy and quite economical to keep the swarf of that material separate from swarf of other materials.

Cast Iron

Cast-iron swarf created by such machining operations as turning, planing, milling, etc., is usually in the form of small chips. The chips, which may take the form of needles or flakes, are brittle, and if dry are also dusty. These factors make it impracticable to handle cast-iron swarf in the same way as steel. Furthermore, steel chips, however small, can be utilised in electric furnaces, but in the case of cast iron, oxidation and loss in the blast make it extremely uneconomical to feed loose swarf to the cupola. Two methods by which these small chips can be successfully remelted are by (1) packing in containers, and (2) briquetting.

The disadvantages of packing in containers are the cost of the containers, and the fact that loss due to oxidation and in the blast still occur to some extent, dependent on how tight the chips are packed in the container. Fortunately, most of these disadvantages can be overcome by the process of briquetting, whereby the swarf is compressed into blocks of convenient size and with a density of at least 70 per cent. that of the solid material. Cast iron lends itself so well to the briquetting process that no binder is required. Fig. 10 shows the arrangement of a complete briquetting plant.

The swarf is tipped into the boot of the elevator by a labourer or by a mechanical conveyor. The elevator carries the swarf to the service hopper, which discharges it on to an automatic measuring table. The press, which is thus fed with chips at a uniform rate, delivers the briquettes on to the machine table. The power consumption of the machine is approximately 12 h.p. when converting about 1 ton per hr. into 600 to 700 briquettes. Where the cast-iron chips are too coarse for feeding to the briquetting press, a tumbler barrel may be used. One end of the barrel is open so that the chips can be thrown in, to be reduced by a roller until they pass through the perforations of the screen. A shute guides the reduced chips from the tumbler barrel to the elevator boot of the briquetting machine.

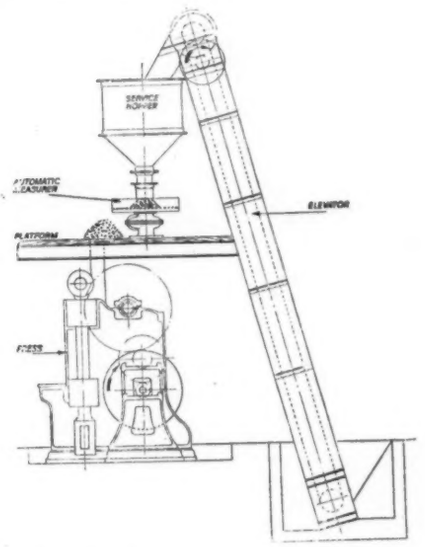


FIG. 10.—ARRANGEMENT OF PLANT FOR BRIQUETTING CAST-IRON BORINGS.

Steel

Steel swarf or sheet scrap can usually be baled or bundled, although in many workshops swarf such as turnings and borings are handled loose by the use of steel bins, barrows, trucks, etc. Some firms, especially those producing irregular, cumbersome sheet-metal scrap, resort to hand baling. Generally the bundles produced by this method are not so compact or uniform as those from bundling and baling machines; nevertheless, if properly organised, the system of hand baling can be made quite efficient.

For plants where machine baling is preferred, reliable baling and bundling presses capable of dealing with a wide range of metal scrap are available. Machines ranging from the simple press to heavy power-driven presses may be used according to the condition and quantity of material to be dealt with. The operation of the hand press is effected through a lever and a ratchet, which actuate a rack and pinion. The size of the finished bales is approximately 9 in. by 10 in. by 8 in., the free scrap having occupied a maximum space of 9 in. by 10 in. by 48 in. The power-driven presses, which are generally hydraulically operated, usually compress the scrap in two stages, using rams at right

angles and often include a third ram for ejecting the bale. The power consumption is approximately 4 h.p. input to the press per cwt. of bale, and machines are available which handle bales of over 3 cwts. and compress the scrap to less than one-third the space occupied before baling. Material which is reduced to a compact form is not only handled and stored more easily, but can readily be introduced to the remelting furnace. Some ferrous scrap, such as fine filings, etc., is so small that it is difficult to handle by any of the foregoing methods. An effective way of dealing with this is to fuse the particles together until pieces sufficiently large for introduction to the furnace are formed. The whole process can be performed automatically and at high speed if an efficient sintering plant is utilised. Such plant includes continuous uniform feeding of the fine chips to a conveyor. The conveyor carries them past a flame which effects the required fusion and leaves a sintered material that can be used in the production of high-grade iron.

Non-Ferrous Metal

Non-ferrous swarf can be treated either in the same way as steel or, as is more usually the case, can be dealt with in machines of the type used for cast iron, for most non-ferrous swarf is easily briquetted. In addition sacks are sometimes used for the storage and transport of non-ferrous swarf.

The ultimate object of the efficient handling of swarf and scrap metal is effective recovery of the material. The nominal value of the scrap may seem small, but the recovered material is of great value, especially under the present conditions of unlimited demand and restricted supply. The final stage of recovery is the actual remelting which cannot be effected without certain losses; nevertheless, by proper preparation, including compact baling or briquetting, some of the chief sources of loss, such as oxidation, are considerably reduced. By the use of a well-arranged cast-iron briquetting plant chips can be briquetted at a cost of less than 7s. per ton, and if included as 10 to 20 per cent. of the cupola charge, it is possible to save up to £1 per ton of melted iron. The briquettes are so compact that oxidation is limited, although the density and structure are such that the graphite is burnt off just above the fusion zone. The carbon lost is not entirely replaced during fusion, so that the final result is a reduction in carbon which permits the production of high-grade castings at a considerably reduced cost.

Aluminium

A reduction in the loss of any material, whether cast iron, steel or non-ferrous metal, is always desirable, but to-day, when aluminium is so vital to our air strength, no effort should be spared in conserving every scrap of this precious metal. It is therefore imperative that all possible steps be taken to prevent the excessive oxidation to which aluminium is prone. The scrap should be well cleaned by degreasing, roasting to remove foreign organic matter, etc., and then baled or briquetted. The presence of moisture in the furnace is particularly harmful, and special care must be taken to ensure that bales are perfectly dry before they are introduced into the furnace. The prepared scrap must be completely submerged in molten metal, so that it is not affected by the oxygen of the atmosphere. Small scrap must not be melted down in the preheating chamber used in the open-hearth furnaces to prevent cooling of the melt by incoming metal. Any fluxes used should also be introduced directly into the molten metal to ensure that they do not act as a medium for the introduction of moisture. If all these precautions are taken, the loss due to oxidation can be reduced to between 1.5 and 3 per cent.,

(*Continued at foot of next column.*)

Book Reviews

Motion and Time Study. By Ralph M. Barnes, Ph.D. Published by Chapman & Hall, 11, Henrietta Street, Covent Garden, London, W.C.2. Price 18s. 6d. net.

"Motion and Time Study" is not a foundry book. Perhaps it is largely on this account that it should be read by foundrymen for, to cast an old adage in a new form, "They Little Know of Foundries who only Foundries Know."

Whymper, the first man to complete the ascent of the Matterhorn, previously spent many years of his life trying. The key to his final success was a distant view of the mountain he obtained from an unfamiliar angle. Before his time, everyone had been deterred from taking the successful route, by a mistaken estimate of the steepness of that particular face. They had all viewed it from the front. In like manner many foundry problems will lose their difficulty when examined from another angle. Dr. Barnes provides a different viewpoint.

Although a rather too simple coremaking job is the only example of foundry work, there is plenty to stimulate foundry thought, and the general reader cannot fail to benefit from the author's careful exposition of the principles of motion. On the other hand, there is much to engage the expert and student. The latter is particularly catered for by a comprehensive bibliography and the inclusion of 52 problems related to the text.

To the average foundryman, the earlier part of the book will have the greater appeal, and a chapter devoted to "Process and Operation Analysis," or what might be described as "macromotion" as distinct from micromotion, is especially important. Citing an example in this connection the author says: "An overall investigation should be the first one made because entire operations or series of operations may be eliminated in this way. It would be a waste of time to have made a minute study of the cleaning and spraying operations . . . with the idea of improving them, only to find later that all of them could be eliminated." On micromotion he says: "Micromotion study should be treated as a tool—something to be used when it is profitable to do so."

Some interesting figures are quoted in a section devoted to fatigue; for instance, the optimum speed for wheeling a barrow is shown to be a normal brisk walk. The mean relative values are given as: Slow walk, 1.12; normal brisk walk, 1.00; very quick walk, 1.68, and gentle run, 1.58. Foundrymen of the older generation, who have had domestic experience, will probably agree with the findings of the State College of Washington Agricultural Experiment Station, which records that, when washing at home, wringing clothes with a hand-power wringer is the most fatiguing operation. The average per cent. fatigue is shown as 197, compared with 99 for a similar appliance electrically operated.

To summarise the contents of "Motion and Time Study" is difficult, in a short review of this nature, for so concisely is it written that it is almost a summary in itself. However, the following headings will give some idea of the ground covered and the order in which the subject matter is presented:—Definition and scope; The pioneers—Taylor, and Frank and Lillian Gilbreth; Extent to which time study may be profitably used; Process and operation analysis; Micromotion study; Therbligs; Motion pictures and film analysis; Fatigue; Motion economy related to the use of the human body; The work place and design of tools; Written standard practice; Wage incentives; Making the stop-watch study; Rating factor; Allowances; Determining time standards for specific jobs, and Training the operator.

Dr. Barnes can speak with authority, for he is Professor of Industrial Engineering and Director of Personnel at the College of Engineering, University of Iowa, where he is in touch with all branches of industry. In his preface to this, the second, edition he records that "during the past three years more than a million measurements of hand motions used in factory operations have been made in the laboratory."

The effectiveness of one type of technique he recommends can be verified by taking a stop-watch board and attempting a trial study. The investigator will see for himself how his own knowledge is improved, and his perception sharpened when he endeavours to make a time study of a particular job.

If this book is widely read, it will do much to correct mistaken ideas of motion-economy principles and lessen the resentment of foremen, supervisors and workers alike when new methods are put into effect. Dr. Barnes hits the nail on the head when he says: "This opposition is largely due to lack of understanding of just what is being done and perhaps, also, to the failure of those installing the new methods to consult others associated with the work in order to get their suggestions."

"Motion and Time Study" is clearly written, adequately illustrated and strongly bound; in fact, it seems to be well adapted to "serve not only as a text-book in technical colleges and universities, but as a hand book in factories, stores, hospitals, homes, and on farms."

A. J. Shore.

Mechanical Testing of Metallic Materials, with Special Reference to Proof Stress. By R. A. Beaumont. Published by Sir Isaac Pitman & Sons, Limited, Parker Street, Kingsway, W.C.2. Price 6s. net.

This concise volume of 120 pages with 82 illustrations has been produced by the author, who is the Superintendent of the Mechanical Testing Laboratory of the College of Aeronautical Engineering, Chelsea, from notes of his lectures and practical demonstrations. In face of the many books dealing with mechanical testing available, there would seem to be little justification for this work if any one of its predecessors dealt adequately with the various factors involved in the carrying out of the routine tests demanded in British Standard specifications. This aspect is dealt with essentially from the angle of the fundamental property of proof stress, with the practical procedure of testing kept in the forefront. The book deals with testing machines in considerable practical detail, in addition to a sound presentation of theory, as well as a chapter on non-destructive testing. It will be found a useful guide to the advanced student of aeronautical engineering and to test-house personnel. The index could have been more extensive in view of the compression of matter in the text.

(*Continued from previous column.*)

which compares favourably with the 1 to 1 ½ per cent. when melting ingots. To avoid the uncertainty regarding the precise composition of scrap, it should be melted in the largest convenient quantities and cast into ingots. Accurate analysis is then possible and effective alloying facilitated.

Increasing Usage of Tantalum

In the form of its cemented carbides, tantalum finds increasing application in wire-drawing dies, cutting tools and wear-resistant parts, either alone or in combination with the carbides of tungsten or titanium, states C. L. Mantell in a review of the minor metals in "Metal Progress." Tantalum has been gaining increasing usage as a material of construction for chemical apparatus, particularly as heat-transfer equipment, in bayonet heaters, hydrochloric-acid reaction apparatus, and as spinnerets for synthetic textile threads and fibres.

Chemical Composition of Killed Steels*

INFLUENCE ON PROPERTIES AND SURFACE

Producers of alloy steel recognise the importance of chemical composition in relation to the hot-working properties and the typical surface defects found in their product. Each analysis of steel has its own peculiar characteristics. Under conditions of standard mill practice each analysis is susceptible to certain types of defects. Mill practice must be varied to obtain the best combination of surface and internal quality in the product.

Chemical composition influences the cast structure and crystallisation characteristics of the ingot. It also determines the rate of heating and cooling, the plastic hot-working range, and the phase structure of the steel at various temperatures, as well as the tendency toward scale formation and decarburisation. This Paper endeavours to emphasise the manner in which chemical composition affects the various properties of steel, and to indicate the relative importance of these factors in relation to the hot-working properties and surface characteristics of killed steel. The influence of chemical composition may be outlined as follows:—

(1) Effect on the cast structure of steel, including: (*a*) State of deoxidation, and type of inclusions; (*b*) gas content of steel; (*c*) freezing point and melting point of steel; (*d*) crystallisation characteristics and segregation.

(2) Effect of the hot-working properties and surface characteristics of steel, including: (*a*) Plastic hot-working range; (*b*) phase structures at hot-working temperatures; (*c*) rate of heating; (*d*) cooling characteristics; (*e*) scale formation; (*f*) surface decarburisation.

Effect of Chemical Composition on Cast Structure

The state of deoxidation is limited by the final chemical analysis desired in the finished product, and is controlled primarily by carbon, manganese, silicon, and aluminium, and to a lesser degree by chromium, titanium, vanadium, or other deoxidising elements. The degree of deoxidation affects the density of the cast structure and broadly classifies the steel as killed, semi-killed, or rimming. This in turn manifests itself in surface characteristics.

The manner and extent of deoxidation also controls the amount, type, and distribution of non-metallic inclusions formed. The equilibrium of manganese, silicon and aluminium with the slags and pouring refractories with which the metal comes in contact is important, especially in regard to inclusions of fire-clay origin. Some surface seams and hot-working difficulties can be traced to non-metallic inclusions.

Gas Content of Steel

Gases may have an indirect effect on the hot-working properties of steel by modifying the forces of crystallisation and segregation in the ingot. Also, they may directly affect the surface to a small degree. The solubility of hydrogen is increased by the presence of certain elements. Steels with high-chromium or silicon contents absorb hydrogen readily.

Nitrogen may be absorbed by steel. Its presence as a nitride in high-chromium steels refines the grain size of the cast structure and increases the gamma field in the solid state. The effect of evolution of carbon-monoxide gas on the structure of rimmed ingots is well known.

Freezing Point (Liquidus) and Melting Point (Solidus) of Steel.—The "freezing point" (the term "freezing point" is used herein to designate the temperature of the liquidus at which freezing begins on cooling, or melting ends on heating. The term "melting point" is used herein to designate the temperature of the solidus at which melting begins on heating, or freezing ends on cooling) of steel is controlled to a large extent by the carbon content and to a lesser degree by other alloying elements. Steels of high carbon content will have a relatively low "freezing point," consequently the amount of superheat above the solidification range can be greater than in low-carbon steels with similar slags and melting facilities. The degree of superheat above the "freezing point" may affect ultimate crystallisation and segregation. Phosphorus, titanium and silicon lower the "freezing point" to some degree, but the effect is negligible, as these elements usually are not present in large amounts. Chromium, when present in large amounts, as in the stainless steels (12 to 18 per cent.), lowers the "freezing point" considerably.

The "freezing point" and the interval between the "freezing point" (liquidus) and "melting point" (solidus) affect the fluidity (or flowing power) of the steel. If the steel is fluid, the elimination of gases and non-metallic inclusions is favoured. Fluidity is also affected by the presence of some alloying elements. Chromium steels are especially sluggish during pouring, probably because of the presence of oxide films. The fluidity of the metal will be reflected in general surface condition by its effect on the mechanics of pouring, such as splashes, umbrella streams, and the rate of teeming. Splashes may cause scabs, and the formation of ingot cracks is affected by teeming rates.

Crystallisation Characteristics

The chemical composition has a pronounced effect on the crystallisation and segregation of ingots, along with other factors. The primary cause of heterogeneity is differential freezing. Carbon, sulphur and phosphorus, elements producing a wide range between solidus and liquidus, show the greatest segregation. Silicon, manganese, nickel and copper show the least because they produce a narrow range between solidus and liquidus. The forces of differential freezing are modified further by the effect of chemical composition on the thermal and physical properties of the steel, such as heat conductivity, specific heat, density, shrinkage, the latent heat of solidification and latent heat of solid transformations. Also, the diffusion rates of the various elements are important, that of carbon being high and those of silicon, phosphorus and manganese low.

The combination of all these factors affects the course of crystallisation. Characteristic structures are found in many steels; those high in alloying elements, such as chromium, nickel, molybdenum and tungsten, have characteristic columnar and dendritic structures. Small additions of some elements, such as titanium, niobium and vanadium, which form highly insoluble carbides, may act as nuclei and materially change the cast structure.

The Seventh Report on the Heterogeneity of Steel Ingots is an excellent reference on solidification, crystallisation and segregation of steel ingots.

The cast structure has a decided influence on the hot-working properties and surface characteristics of steel. Planes of weakness are found where the crystals growing from two faces meet, as in the columnar zone of ingots.

Plastic Hot-Working Range

Various factors influence the magnitude of the forces under which a material will yield plastically, according to Nadai. The magnitude of stress necessary to produce plastic flow decreases with increasing temperature. The modulus of elasticity and modulus of rigidity of metals decrease with increasing temperature. In general, the plastic working properties of pure metals of the same structure are similar, at the same ratio of the absolute hot-working temperature to the absolute melting temperature. By dissolving a foreign substance in a metal the resistance to plastic deformation may be greatly changed.

The practical hot-working range of steel lies between the minimum temperature at which the steel can be deformed without rupture or breakage with the available equipment and the upper temperature limitation where "burning" may occur. This range may be narrow with some steels; with others it is fairly wide. The hot-working range is largely controlled by carbon content and to a lesser extent by the presence of other alloys.

At low temperatures (below 870 deg. C.) steels of high-carbon content have a higher resistance to deformation than low-carbon steels. With high temperatures the resistance to deformation of high-carbon steel may be lower than low-carbon steel. For customary rolling temperatures, however, the resistance to deformation increases with increasing carbon content, inasmuch as the rolling temperature of steels with higher carbon contents is lower.

High-alloy steels, such as the austenitic types, have several times the resistance to deformation of plain carbon steels. In high-alloy steel, with high reductions by rolling, the resistance to deformation may be higher than the resistance to rupture, so that cracking may occur.

Resistance to deformation drops rapidly for all steels as the temperature is increased; however, a low temperature may be desirable for holding section, and lessening scaling and decarburisation.

Spreading is affected to a marked degree by composition next to other factors, such as rolling speed, temperature, roll diameter and roll surface. Ferritic-chromium steel and high-silicon transformer steel show the greatest spread of the common alloy steels. Forward slip (a forward flow at a higher velocity than the peripheral speed of the rolls, depending in a large measure on the friction of the rolls) drops little with increasing rolling temperature with carbon steels, while it shows an appreciable drop with high-alloy steels.

The upper limits of hot-working temperature are determined by the temperature at which fusible constituents in the steel will melt and penetrate into the grain boundaries and leave voids between the grains. The theoretical upper limit for plain carbon steels is the solidus line of the iron-carbon diagram. Alloy content affects the position of the solidus line slightly, but carbon exerts the greater effect.

Certain elements may produce hot-shortness or cause surface defects in steel. Sulphur, tin, arsenic, antimony and boron will produce hot-shortness; the degree may vary with the carbon content of the steel and the presence of other elements. If such elements are present in undesirable amounts, the hot-working range is narrowed to such a degree that often the steel cannot be hot-worked satisfactorily.

High sulphur content in steel may cause hot-shortness. Proper deoxidation and sufficiently high manganese content will lessen hot-shortness in sulphur steels. The method of addition of sulphur is also known to have an effect.

Little is known of the cause of red-shortness produced by antimony, arsenic and tin, although 2 per cent. will close the gamma loop. Tin contents as low as 0.15 per cent. will definitely

* From a Paper by Gilbert Soler, published in "Metals Technology."

affect the surface condition of steel. Copper will produce poor surface on steel unless sufficient nickel or molybdenum is present. On reheating for the sinking operation, the bronze (60 per cent. Cu) penetrated into the surface of the tubes, causing spiral cracks on subsequent hot-working.

Phase Structures

Most steels have an austenitic structure at hot-working temperatures, although the ferritic structure (delta iron) is found in certain types, such as the high-chromium steels. Mixed phases consisting of austenite and ferrite (delta iron) may occur at hot-working temperatures. Undissolved carbides and non-metallic inclusions (oxides, silicates, sulphides, nitrides, etc.) may also be present. Mixed phases generally result in poor hot-working characteristics.

The effect of the various alloys on the position of the A_3 and A_4 transformations of iron, thus defining the gamma or austenitic range has been studied by F. Wever. E. C. Bain has classified the distribution of elements at elevated temperatures in steel as:—(1) Dissolved in the gamma iron solid solution; (2) combined with carbon to form persistently insoluble carbides; (3) combined with other elements to form special compounds or non-metallics.

The most insoluble (inactive) state forms preferentially until one or the other element involved approaches depletion, after which the element concentrates in the remaining possible combinations.

The ratio of niobium to carbon in the piercing of 18 per cent. Cr, 12 per cent. Ni steel is an example of this principle. When the ratio of niobium to carbon exceeds 12:1 poor piercing is the result. Evidently this is due to the formation of niobium oxide after the carbon has been satisfied by sufficient niobium.

Rate of Heating.—The rate and amount of heating of ingots is determined by the extent of cooling that has occurred after the ingots are solidified and by the chemical composition as effecting the physical characteristics of the steel. Cold steel may be heated for rolling or forging in ingot form or as blooms, billets or bars. Ordinarily more care must be taken in heating ingots because of their size and the segregated structure resulting from casting.

The physical properties affected by chemical composition as influencing the rate of heating and cooling are thermal expansion, heat conductivity, specific heat, and density. Not only must the general effect of physical properties be considered, but also the thermal stresses that are set up by either cooling or heating through the critical range.

The rate of heating or cooling for different alloy steels, other than through the critical range, is not affected greatly by thermal expansion. At low temperatures the high-alloy steels have much lower thermal-conductivity values than plain carbon steels, but all steels appear to approach a common value at higher temperatures.

The specific heat of iron increases at a fairly rapid rate to the critical range; there is a momentarily large increase to the A_2 transformation, then a rapid drop to the A_3 transformation, with a slow increase in the gamma range to the A_4 transformation. Specific heat of steel is increased to a fair degree by nickel content and slightly by silicon content. The values for the density of steel are of especial importance at the alpha and gamma critical transformation.

Steels high in chromium and nickel content (stainless steels) appear to have low thermal-conductivity values compared to carbon steels. These steels must have lower heat-diffusivity values, for it is necessary that they be heated and "soaked" for a longer time than plain carbon and low-alloy steels, so that a large differential of temperature does not exist between the centre and surface of the section being heated. Conversely, it is to be noted that the centre lags considerably behind the outside on cooling.

Thermal stresses set up by transformations through the critical range are important—not only the amount of volume change, but also the temperature differential between various parts of the section, especially in the cast structure of ingots and the temperature at which the transformation takes place. The transformation temperatures are generally lowered by carbon, manganese and nickel. A slow rate of cooling or heating through the critical range is necessary if longitudinal cracks are to be avoided in certain steels.

The chemical composition definitely defines the phase structure found at plastic hot-working temperatures as well as the critical range of the steel. Grain growth must be especially considered in the austenitic and ferritic steels. The absence of a transformation at heating temperatures precludes grain refinement due to a phase change produced normally in the pearlitic and martensitic steels by heating through the critical range. Grain coarsening in the austenitic and ferritic stainless steels will occur at temperatures below the hot-working range. Because of their low thermal conductivity these steels must be "soaked out" below the grain-coarsening temperature (815 to 910 deg. C.), then raised rapidly in temperature to the plastic working range, as grain coarsening is an important factor and must be avoided.

Cooling Characteristics

The effect of chemical analysis on thermal and physical properties as well as the position of the critical range controls the formation of differential stresses that may occur during cooling. Jagged cracks may develop on the surface of rolled sections during cooling. The tendency to harden on air-cooling may directly affect clean-up costs; owing to an increased surface hardness. Steels of over 0.35 to 0.40 carbon will be harder under the chipping hammer when air-cooled in bloom form than steels that are slow-cooled.

Phase transformations may be helpful in loosening and cracking off adhering scale by the expansion that occurs when steel is cooled through the critical range. Phase transformations as influenced by the manner of cooling may be manifested in surface difficulties in subsequent hot-forming operations. High-carbon graphite steels must be cooled quickly in air; otherwise graphite is precipitated in hot-working the steel. Certain austenitic steels must be cooled quickly in order to retain the proper phase structure.

Scaling characteristics largely depend on chemical composition. Published researches have been directed mostly to studies of scaling losses for long periods of time at temperatures below those used in the hot-working of steel. The amount of scale formed in the comparatively short times required for heating ingots and billets for rolling and forging does not vary considerably between various alloy steels. However, the adherence of the scale to the steel and its ability to flake off in the rolling or forging operation is very important. Tightly adherent scale is characteristic of nickel steels.

Surface Decarburisation

Surface decarburisation is an important factor in many steels and must be kept to a minimum, especially in medium and high-carbon steels where the stock clean-up on the finished product is not sufficient to remove the decarburised zone. It is altogether possible that a highly decarburised steel may not hot-work properly because of the difference in composition of surface and interior.

Surface decarburisation is lessened by chromium, titanium, and vanadium, and it is increased by nickel and molybdenum, at temperatures of hot-working. It must be kept in mind that decarburisation is affected by time, temperature, and heating atmosphere to a large degree, consequently the heating times and temperatures required for certain alloy steels may be such that the rate and degree of decarburisation is increased.

Concluding, the author summarises as follows:—

The chemical composition of killed steel has a decided effect on its hot-working properties and surface characteristics. Composition limits the state of deoxidation, influences the gas content, and controls the freezing range. It also determines the physical properties of the steel that modify the thermal behaviour of the ingot during solidification. The combination of these factors controls to a large extent the crystallisation characteristics and cast structure of the metal.

The phase structure and hot-working properties of steel are influenced and limited by chemical composition. Physical properties restrict the rate of heating and cooling of the steel; especially in the transformation range. The extent of scaling and surface decarburisation is modified by the chemical composition of the steel. Examples showing various surface defects in alloy steels have been discussed.

American Society for Testing Materials

1940 PROCEEDINGS

The Proceedings of the 1940 annual meeting of the American Society for Testing Materials, just published, include the many important committee reports and other material presented at the annual meeting, and the technical Papers and discussions affording valuable data and information on the properties and tests of engineering materials. The new edition covers some 1,400 pages.

Not only do the reports of A.S.T.M. committees give full details of the various recommendations on specifications and standardised test methods for materials but in many cases they include useful data and information in the form of appended reports or Papers. Nine of the reports pertain to ferrous metals, including steel, cast iron, corrosion of iron and steel, magnetic properties, malleable iron castings, fatigue of metals, effect of temperature on the properties of metals, and iron-chromium-nickel and related alloys. The latter report includes an appended item on inspection of stainless steel architectural structures. Other appended Papers cover a study of effect of variables on the creep resistance of steels and a list of published reports with reference to tests on 0.35 per cent. carbon steel K20.

Seven reports involve non-ferrous metals including copper and copper-alloy wires for electrical conductors, non-ferrous metals and alloys, corrosion of non-ferrous metals and alloys, electrical-heating, electrical-resistance, and electric-furnace alloys, copper and copper alloys—cast and wrought, die-cast metals and alloys, and light metals and alloys—cast and wrought. There are extensive reports covering cement, clay pipe, fire tests of materials and construction, lime, refractories, concrete and concrete aggregates, gypsum, mortars for unit masonry, concrete pipe, and manufactured masonry units.

Copies of the 1940 Proceedings can be purchased from the A.S.T.M. headquarters, 260 S. Broad Street, Philadelphia, Pa., at $8.50, heavy paper binding; $9.00, cloth; $10.00, half-leather, postage prepaid.

Phosphor Bronze Castings of Heavy Section

A LANCASHIRE DISCUSSION

A meeting of the Lancashire Branch of the Institute of British Foundrymen was held at the Engineers' Club, Manchester, on March 1, Mr. W. Holland, Branch-President, in the chair.

The BRANCH-PRESIDENT, in calling upon the author to read his Paper, said it would be the first one on non-ferrous castings which had been presented during the course of the Session. The Paper had been already read to the London Branch of the Institute,* and for which the author had been awarded the Institute's diploma.

Vote of Thanks

Upon the motion of MR. E. LONGDEN (Manchester) a hearty vote of thanks was accorded to the author for his Paper. Mr. Longden stated that he entirely agreed with all that the author had said in connection with the methods of making very large bronze castings. Doubtless, during the course of the discussion, there would be some opportunity to dot the i's and cross the t's of what had been said.

MR. A. SUTCLIFFE, SENR. (Bolton), seconding the vote of thanks, referred to the pillar which had been chilled all over, and an illustration of which had been shown upon the screen. Would it be suitable for making a spun casting, because it appeared likely that the chills would densen it.

The vote of thanks was carried unanimously by acclamation.

Limitations of Spinning

MR. HOPWOOD, in acknowledging, also answered Mr. Sutcliffe's question concerning the use of chills. There was a saying that there was nothing new under the sun, and he had no desire to infer that any of the ideas presented to the Paper should be regarded as new. What he wanted to point out was that the Paper was the assembling of practical experience tending towards the successful production of a casting. Chills never were intended to be the be-all and end-all of successful foundry practice, but nevertheless they could not easily be replaced.

With regard to the spinning of the wheel which had been referred to, the bore of the one shown on the screen was about 4 in. dia. A machine cut of ¼ in. would reduce it to 3¾ in., and it could be visualised what an excessive speed would be necessary in order to get the bore completely solid. He did not insist that it could not be done, but coupled with that suggestion was the consideration of the expense of the metal bowl which it would be necessary to mount on to a machine. He thought the total number which were made were all to replace worn-out castings, and as far as he could remember not more than half-a-dozen were produced. Therefore, it did not appear to be an economic proposition.

MR. KILBURN SCOTT (London), referring to a bronze casting which was more dense at one end than the other, said that this would be difficult if it was made as a spun casting. He remembered Mr. Joseph Whitley, of Leeds, who achieved such results round about the year 1870, or about the time that Cleopatra's Needle was brought to this country, an action in which Mr. Whitley was personally interested. Cylinder bronze castings for paper-making machines had been made practically ever since then, and Mr. Whitley thought the casting would be a much better one if it was spun. The place where the greatest density was required was clearly on the periphery where the teeth were. Instead of making them in 1⅛ in. lengths, a long one would be spun, and parted by machining; thus there would be no head. He noted that the lecturer had stated there was only a 2-in. head. This surprised him because the head on a sealing gate was very much larger. Was any silicon used in the castings as was the case with steel, in order to eliminate the gases and to keep the metal liquid?

Degasifying by Atmosphere Control

MR. HOPWOOD, answering Mr. Kilburn Scott's last question first, said silicon was not used, though it was used in non-ferrous metals in some cases for the reduction of oxides. With regard to the degasifying of non-ferrous metals, there were certain fluxes on the market which were said to degasify bronze, after which it was necessary to deoxidise. These fluxes had a certain scope for use, but possibly the best way to degasify bronze was to keep the furnace atmosphere in a suitable state by maintaining slightly oxidising conditions. It had been proved more or less, but experiments were still being carried on, that the gases causing trouble in non-ferrous metals were definitely reducing gases. Hydrogen was a source of trouble in copper in the melting period; that is, when it was first put into the pot. As it became hotter, it absorbed hydrogen from the gases before it melted; during melting, and whilst superheating, it absorbed them to a still greater extent.

The question of gas, to his mind, resolved itself more or less into a question of furnace atmospheres. If an oil-fired furnace was used, the necessary steps could easily be taken. The melting of the metal could take place under a reducing atmosphere which would give almost the same temperature. The metal did not melt quite so quickly, but the castings made from it would be very porous; whereas by melting in a reducing atmosphere, and then when the metal was molten changing over to an oxidising atmosphere, the gas pick-up could be nullified to a great extent, for it seemed to reduce the amount of gas picked up.

The fluxes on the market were oxidising mixtures which were stirred into the metal, or plunged to the bottom of the melt, and the melt was oxidised in the same way as in a furnace carrying an oxidising atmosphere. Then it was necessary to reduce the oxides created by the oxidising mixture by the use of a deoxidiser and by having a correct atmosphere when finishing.

Advantage of Spun Castings

He had had a fair amount of experience with regard to the spinning of phosphor bronze wheels. Mr. Kilburn Scott was perfectly correct in what he had stated. There was nothing to surpass a spun casting; a 22-lb. casting made "sand-cast" would weigh 24 lbs. when spun-cast. From this the densening effect of spinning was evident. These 22-lb. wheels were machined to very fine limits and inducing an extra 2 lbs. per casting, would enable one to appreciate the value of spinning over ordinary methods.

However, a large number of castings were necessary in order to make spinning an economic proposition, unless, of course, the type was a very simple one. He had spun one-off castings by adopting a machine specially lending itself to this purpose; but it was more or less a combination of the two processes of using loose chills and sand built into a spinning machine. The mould was made in the machine with the chills in position, dried, and then closed down. The machine was spun and the metal fed into it. This had been done for odd wheels.

With regard to the question of the nut, a horizontal machine would be required initially. He doubted very much whether it would pay to build up a mould, turn it horizontally on its side, and spin it. Probably the mould could not withstand this treatment. Then there was the difficulty with small bores of getting them sound. The difficulty with both the horizontal and vertical machines was in producing small diameters. It could be done with a bush, because there was very little difference between the outside and inside diameters. With a large outside diameter and a very small bore, it was a different problem altogether.

MR. E. LONGDEN (Manchester) also referred to spinning. The minimum peripheral speed required to give the requisite density was approximately 1,400 ft. per min., though in his opinion 1,500 ft. per min. was a safe spinning speed. In the case of a small diameter it could be imagined at what a terrific speed the mould must be spun; added to which there must be considered the economic factor of the small orders. These considerations exceeded the economic possibility of the case in regard to any attempt to spin. The lecturer had pointed out in the case of a spiral gear that it had to pass the inspection, but in addition it had also to have a life, which if not attained resulted in a complaint.

Where the Metallurgist Fails

MR. SUTCLIFFE, SENR., said the successful production of a non-ferrous casting needed a perfect mould, and in this respect the moulder had done all within his power to accomplish this result, and a mould could be produced which was satisfactory. Why did not the chemist or metallurgist provide a suitable metal, and abandon the attempt at a solution of the problem when the result was faulty? If there were a mishap with the casting the chemist or metallurgist could always find an explanation which exonerated himself. If the customer wanted a gunmetal casting then he must pay for the tin. There was no credit given him if he was being supplied with 8 per cent. instead of 10 per cent. tin. If the product was taken, say, next door for analysis, and then taken somewhere 20 miles away, the analyses would so differ that no fine could be imposed. This should not be forgotten, because it was what had happened!

Ordinary bench sand was now being commonly used for moulding, and he had not experienced difficulty with regard to it. He could produce details for core-making and for sand-facing mixings, but the metal had great tendency for burning on. He particularly desired information concerning corrosion-resisting alloys because many of the castings used in the Lancashire area had to withstand the effects of corrosion, especially those used in the very considerable bleaching industry.

For large non-ferrous castings, a cupola of the type shown in Fig. A had been successfully used. This small cupola had one blast pipe so that the blast would not be too great. A certain amount of large coke was used. The holes numbered 1 and 2 on the sketch were so placed in order that the cupola could be repaired.

Would Mr. Hopwood expect to achieve good or bad results in the metal from such a cupola, and would it be a better proposition than either the rotary or the pot furnace? It was not a new type of cupola, but was in use about 46 years ago. It could be seen that there was no contact with coke when the metal was in the receiver portion.

* Vol. LXI, p. 285, *et seq.*

Sands for Non-Ferrous Practice

Mr. Hopwood remarked that the metallurgist was a very useful man to have about a foundry. The complaint was sometimes voiced that the metallurgist had appropriated to himself all the best jobs of the industry. This was a fallacy, and if the foundryman would only learn more about the metals with which he was dealing no such question would ever arise. Whenever a foundryman dealt with a new alloy, the first thing he should study before making his mould was the properties to be associated with it.

Generally speaking, in the case of non-ferrous foundries, sand had not the same importance that it had in the case of ferrous metals, which involved higher casting temperatures. Thus extreme refractoriness of the sand was not necessary, and therefore the same problems were not experienced. Sand was a porous mixture, carrying spaces between the grains and the binder. Speaking broadly, the gases expanded according to the temperature attained. Therefore the trouble of the evolution of gas from sand had not the same importance. The use of fine sands in non-ferrous foundries could be over-done, though many people favoured them. It was satisfactory for small work such as bench work. In the case of very heavy sectioned castings, where the metal lay not only in contact with it but remained in contact with it in a liquid or semi-plastic state, then a different set of conditions would arise. The gas was still expanding, and was liable to push its way into the pasty mass. Most cast irons are different, inasmuch when the metal comes in contact with the sand, a skin of rapidly solidifying metal forms, which resists to a great extent the tendency of the gases to flow into the solidifying metal. He found that by using a coarse sand for heavy non-ferrous work and using a good blacking mixture was very advantageous for a dry mould. This involved using a coarse green sand, ramming firmly, and making sure that the mould retained its original size throughout the cast. He wished to stress this point because many castings were scrapped through the statement that wrong casting temperature was being used and was responsible for the faulty fracture and red patches, the presence of which was not always attributed to the correct cause. They could be ascribed to the inferior ramming of moulds.

Risers for non-ferrous metal castings was a problem in itself, and more risers should not be put on than were necessary.

Corrosion-Resisting Alloys

The subject of corrosion resistance was bound up with service conditions. It was usually found that the people who required castings to be made with non-corrosion resisting alloy or partly-non-corroding metal stipulated the use of their own mixtures. Such alloys were usually zinc-free. He remembered, when he was an apprentice, making cocks and plugs in phosphor bronze to withstand pressure, and he remembered also the foreman's method of overcoming the difficulty. Several batches were made, but they could not withstand the pressure; not because they were incorrectly fed, but because the alloy was naturally porous. The kind of alloy to be selected, of course, depended upon the liquid or other conditions with which it had to deal.

Available for this purpose were lead-antimony mixtures; phosphor bronze and nickel alloys, all used for different services.

Cupola for Non-Ferrous Work Condemned

The melting of non-ferrous metals in cupolas depended upon the particular conditions arising in the furnace used. There were troubles in melting brass in crucibles, and there was added difficulty in melting these alloys in open-flame furnaces. There would be a still greater difficulty in obtaining consistent results by melting in a cupola. It could be done, but he would not like to say he could produce the same results in that type of furnace as could be produced in an open-flame furnace or a crucible furnace. The less non-ferrous metal came into contact with the fuel, or with the gases, the better the type of metal produced. Test bars proved this to be correct. Melting in a cupola furnace could be broadly stated as having the bed coke to retain the charge above the tuyeres, and to charge the coke to replace the coke which was burnt, and so on. The metal was in actual contact with the heat-producing fuel. The condition prevailing in the melting zone was, it might be said, the critical point in the type of metal produced. If there was a heavily oxidising atmosphere in the melting zone, that is, there was a considerable amount of air being blown in, the condition would be an oxidising one, and there would be heavy metallic losses. There would be a considerable amount of oxide formed. If there was a melt of copper alone and an alloy addition later, then the oxide would be dissolved in the copper, and when it came down into the well or collecting chamber it would have to be reduced before adding the mixing. If there was any charging of ready-mixed alloy, which mixture contained such constituents as zinc and phosphorus, which were easily oxidised, then the losses of those constituents would be very considerable. He would not be surprised to learn that all the phosphorus had disappeared. If tin were present in conjunction with zinc, then after the zinc burnt out, or perhaps simultaneously, some of the tin would also be oxidised. The tin oxide would come down with the liquid running into the bottom, and if the castings had to be pressure-tested they would fail to pass inspection.

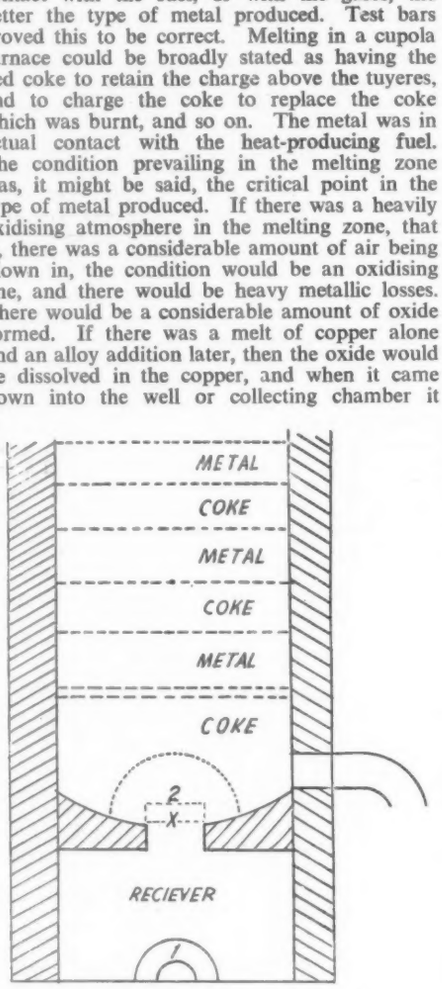


Fig. A.—Cupola utilised for Melting Non-Ferrous Alloys.

Mr. Longden said that the question dated back to the old days when there were not sufficient furnaces. Apart from that point, he did not think the matter need now be considered.

Mr. Hopwood thought the difficulty lay in the atmosphere of the furnaces and the oxidising effect, and added that the trouble with copper, or with any non-ferrous metal, would lie in the actual melting zone, and not in the well. Molten copper could be kept in contact with coke, and there would be very little effect as a result, particularly in the case of low-sulphur coke. In fact, there might be an advantage, as any copper oxide produced in the melting zone may be reduced.

Cast Phosphor Bronze Sticks

Mr. E. White (Stretford) raised a point with regard to cast bronze sticks. Could Mr. Hopwood suggest any particular type of tackle, through the use of which it was possible to have a minimum of machining done on the sticks, and at the same time to obtain the Brinell hardness required without excessive machining.

Another rather important point in production was in connection with the large risers used on some of the small brass castings. It seemed, to an ordinary individual who knew very little about the matter, as though there was a great deal of wastage caused thereby. There must be a considerable cost in terms of money. Getting down to fundamentals, when one had to quote definite prices, a clear indication was given that brass founding would decline, and that some metals, such as magnesium, which for small castings could be die-cast, as is the case in the aircraft industry, would become very commonly used, particularly as they required little or no machining. How was it possible to reduce this extravagance? Because, when a moulder made a mould many times, he was not too cautious and did not think about an extra pound or two of metal. It all cost money. In order to achieve the results which were necessary at the present time, a minimum of machining and a maximum of efficiency were desirable.

Mould Dressings

Mr. Hopwood said that normal practice was to chill-cast phosphor bronze sticks. The chills in some cases were full chills carrying a slight taper, but very often they were half chills put together by a male and female joint, and then clamped. This was a very successful method of production; but there was still the difficulty that the chills had to be dressed and cared for in the proper way. The Brinell hardness was far higher than that which the same alloy would give in a sand casting. The production of sticks in sands was a bugbear.

Risers were every brass-founder's trouble. The fettling cost of non-ferrous work was something upon which it was necessary to maintain a constant supervision. Very often the solution of the question crystallised down to the proper shape of a riser. The majority of brass-founders frequently put on a straight cylindrical riser, whereas one with a narrow neck, where it joined the casting, would be more economical in fettling cost and still answer the purpose. When he referred to a paper riser, he meant that a riser of that description was not, in his opinion, a successful proposition, because very often the metal would lie on the face. The size of the necks was a wide question, and depended upon the alloy and the particular conditions and shape of the casting. No one could give particular advice on the matter, but the fettling cost would be considerably decreased through adopting such a riser and narrowing the neck. The reason was that the neck became so hot that it approximated the same temperature as the metal itself, and the sand forming the neck retained the heat.

Reducing Remelting Costs

Mr. White remarked that the point he wished to emphasise was that of reducing the cost of the actual casting by minimising the amount of metal, because it all required remelting. He thought it was a point worth consideration.

Mr. Hopwood, agreeing, said it was a question of the shape of a casting. No one could help very much with regard to the actual problem until they saw the casting and the thickness of the particular section it carried. Many castings had risers which were unnecessary. Much riser work could be eliminated by

increasing the amount of head pressure. Even manganese bronze castings could be cast without any risers, but has a high head pressure. Castings of even sections which would normally carry a riser equal to their own weight had been cast successfully in manganese bronze by means of high head pressure.

Running Methods

Mr. H. Haynes (Ashton-under-Lyne) referred to the horizontal runners used on the castings, wherein the section of the casting was larger than the down runner. For instance, one slide showing five gates, apparently of greater section than the down runner. It also occurred to him that for running the castings, two down runners would feed better than one large one, which was liable to cause a swirl and take the scum down into the casting. In the case of another illustration, he noticed there was a 2-in. down runner, and he thought the in-gate was ½ in. or 1½ in. He was speaking as an iron founder and was not particularly experienced with regard to brass founding. The thought had occurred to him, why not have a 1-in. down runner supplying two gates, or to have a 2-in. down runner leading to the four gates?

Mr. Hopwood replied that it should be realised the top bush was a standard piece of tackle, and to utilise it the two down runners were taken on to each side of the casting. The size of the intake of the metal was controlled, and no dirt could get into the casting. It was not, as in the case of molten iron, where the metal was usually at a temperature far in excess of its melting point, but one of controlling the running in so that it was introduced much slower. The non-ferrous metals must be quickly and smoothly delivered to the mould.

Pouring Phosphor Bronze Sticks

Mr. F. Andrews (Oldham) asked, if he desired to cast a stick 4 in. dia. in phosphor bronze, having 9.5 per cent. tin and 0.5 per cent. phosphorus for hardness, using a chill mould, would it be advisable to keep the mould vertical or to tilt it? What would be the best dressing?

He was pleased to find that Mr. Hopwood spoke about gas absorption, because too often much was said about oxidised metal when it was actually a case of gas absorption. The trouble was with gas absorption in most cases, and, owing to the gas not escaping, pin-holes were formed in the casting.

Mould Dressing Details

Mr. Hopwood said that quite often mould dressing was over-done. Many people had used dressings, but he had found that keeping the chills at the correct temperature, and maintaining the correct casting temperature, was much more helpful than the use of any fancy dressing. The material which he did use was an ordinary lubricating oil and plumbago dressing. If it was necessary to stiffen it, the introduction of linseed oil on to a hot mould put a hard face on it. Or, if it was necessary to stiffen an ordinary oil dressing, then resin could be used, or else a thicker oil base like lard oil. A thicker oil than a lubricating oil could be used, and one with a little higher flash point.

He would pour the sticks vertically, because not only did the gas from the mould dressing rise more naturally, forming a cushion between the metal and the side of the chill, but metal running on to the bottom chills was more apt to give trouble. If there was a chill on the bottom more care had to be taken than if the same chill was up the side.

Temperature Control

It was possible to cast phosphor bronze sticks in chills at the same temperature as with an ordinary sand mould. This could always be taken as a reliable guide; if there was available

(*Continued at foot of next column.*)

Sound Malleable Castings

DISCUSSION IN EAST ANGLIA

When Mr. Wood's Paper* on this subject was read at Ipswich, it was well received, and what follows is a *résumé* of the discussion.

Mr. J. Francis said it appealed to him as a good point in melting steel scrap to mix large and small pieces together as an aid to more uniform melting and less oxidation loss. He also emphasised the importance to the war effort of a process, such as had been described, which allowed of iron castings replacing those of steel in certain circumstances and to a greater extent. Another point was the effect of section thickness on the annealing process. Were thick and thin castings classified? The lecturer had stressed the importance of metallurgical control at all stages, and Mr. Francis said he could easily appreciate this with a material requiring such close limits of composition and with the difficulties occasioned by its naturally high shrinkage.

Mr. C. H. Kain congratulated the author upon the excellence of the photomicrograph with which the Paper was illustrated. He also commented upon the composition of the white iron as given by the lecturer, saying that it seemed rather high in sulphur. Was the melt desulphurised by soda ash? Did the author deliberately employ such a high sulphur figure or was it accidental? Referring to the inert material in which the castings were annealed, Mr. Kain said that he had found burnt slag to have a greater heat-conductivity than sand. The annealing temperatures given were higher than for rotary furnace malleable where 880 deg. C. was a maximum figure.

Mr. Hammond also raised the point whether thick and thin castings are annealed together in the same pot. He also asked whether loose packing or air spaces had any effect on the anneal.

Mr. L. Davy asked if, in view of the difficulty of control of the last charges melted in the cupola when using steel scrap, the blast was cut down.

Mr. T. Ruffle inquired as to what fuel was used in the annealing ovens and the composition of the oven atmosphere. He also asked if a coarse grain developed by high-temperature annealing could be restored by subsequent heat-treatment.

Mr. D. Carrick, referring to core practice, asked whether it needed modification to suit malleable cast iron. He also asked for a comparison between black-heart malleable and mild steel for strength.

Author's Reply

In reply, the Author thanked all those who had made complimentary remarks on his Paper. Dealing with the question of section thickness, he said it did not effect speed of annealing, but did effect the heating up. The castings were sorted and the thickest ones were placed in the hottest part of the oven, experience being the guide. Packing material used in the black-heart process was only to prevent sagging or warping of castings.

The high sulphur came chiefly from the hard scrap and was normal for cupola-melted white iron. Malleable castings made from the rotary or air furnace were annealed at lower temperatures, as they usually were of high-class requirements where small grain size was desired. The annealing time would, however, be longer.

With respect to Mr. Davy's question, Mr. Wood said that iron from the last few taps tended to melt whiter and hotter, and the blast was cut down. The fuel for the annealing ovens was pulverised coal or fuel oil. Oxygen in the ovens was below 1 per cent. It was possible to refine a coarse grain caused by high annealing temperature by subsequent thermal treatment.

Cores for malleable iron castings must be as soft as possible; otherwise there was a danger of hard iron cracks. Black-heart malleable had a tensile strength equivalent to that of 0.1 per cent. carbon steel, but the ductility is less.

Mr. H. H. Shepherd (Branch-President) congratulated Mr. Woods on the Paper and illustrations. He said there was not much latitude in the manufacture of cupola black-heart malleable, rather less than for white-heart. Air-furnace malleable was lower in total carbon and sulphur and higher in silicon.

(*Continued from previous column.*)

experience of casting in sand moulds, then chill casting could be carried out at the same temperature. There was an upper and lower altitude limit.

Mr. Andrews asked how Mr. Hopwood ascertained whether the temperature of the metal in the furnace was adequate, and did he take the temperature at the furnace?

Mr. Hopwood said that he used an immersion-couple pyrometer after withdrawal. It was usual to melt the metal in the furnace until it was thought to be the correct temperature and then withdraw. He must admit that this was not always the best practice, but it was the method which was carried out, due to the liability of damage to the thermocouples.

Mr. Andrews said, in his experience, temperature was taken in the furnace, because it was not desirable to return the crucible through the metal being insufficiently hot.

Mr. Hopwood replied that if a standard alloy was used, the furnacemen became very adroit at judging temperature; in fact, they became too clever and started casting the jobs without taking any temperature test at all. This often led to trouble.

Mr. Sutcliffe, sen., referring to the bush or stick of approximately 4 in. dia., mentioned by Mr. Andrews, asked whether it would answer to cast as with a chill bowl.

Mr. Andrews pointed out that large quantities were called for.

Mr. Sutcliffe, sen., said the job could be made as if it were a chill bowl. By using two necks—one at the top and one at the bottom—the bottom one having a spinning runner, success could be achieved, for the action of the metal entering the mould would result in a spinning effect directed toward the centre.

* See our issues of March 13 and 20.

Die Castings in Magnesium Alloy

(*Continued from page* 242.)

Design and Machining

The design of die castings in magnesium alloy is generally similar to that in other alloys suitable for die-casting. Dimensional limits which can be held are substantially the same as for aluminium alloys and are only a little wider than for the alloys of lower melting point. Thus, the tolerance as between points in solid parts of the die is plus or minus 0.0015 in. per in. Somewhat thinner sections can be die-cast in zinc alloy, but the number of castings calling for unusually thin sections is not very large. Fillets at interior corners are desirable, as in all castings, and suitable drafts must be allowed for cores and on side walls to facilitate removal from the die.

Machining of magnesium alloy die-castings is readily done, as the metal machines freely. As fine chips are readily ignited, however, it is recommended that an oil-type coolant be employed, especially as its use may also contribute to the smoothness of cut and may increase the allowable machining speed.

Influence of Turbulence on the Structure and Properties of Steel Ingots

Dr. L. Northcott, in a Paper entitled "The Influence of Turbulence on the Structure and Properties of Steel Ingots," which he has prepared for presentation to the Iron and Steel Institute, has summarised his work in the following terms:—

Seven 15-cwt. killed steel ingots have been cast from the same melt by different methods to determine the influence of turbulence. The methods employed involved: (1) Bottom casting, (2) top casting, a single stream down the centre of the mould, (3) the use of a multi-hole tundish, (4) a sand mould with a single stream, (5) a single stream near one side of the mould, (6) top casting with a single stream, stirring with a poker after casting, and (7) casting with a sloping mould. Information on the turbulent conditions occurring with these methods was also obtained by casting under similar conditions a series of small composite alloy ingots composed of a red alloy and a white alloy. Axial slices of the steel ingots were examined for chemical segregation, crystal structure and mechanical properties. Some of the results obtained may be summarised thus:

(1) The casting method offering least turbulence was the one using the multi-hole tundish. In order of increasing turbulence this was followed by bottom casting, top-casting with a single stream down the centre, with a tilted mould, with a single stream near one side of the mould and the poker-stirred methods.

(2) The structure of the tilted-mould ingot was very unsymmetrical; the lower side down which the stream was poured was composed of small equi-axial crystals, whilst large columnar crystals grew from the opposite face.

(3) The poker-stirred ingot showed a pronounced banded structure, the bands being approximately parallel to the mould wall and extending almost to the middle of the ingot.

(4) The sand-mould ingot was characterised by excessive piping, owing partly to the penetration of the first-formed skin by the liquid on the inside, a coarse primary crystal structure and pronounced A-segregation.

(5) The ingot cast with a single stream near one side of the mould showed a patchy form of A-segregate.

(6) In general the A-segregate showed a strongly dendritic structure as compared with the nodular structure of the purer metal on either side of the segregate.

(7) Measurements were made of the columnar crystal length and orientation in the different ingots. Most of the columnar crystals were inclined at a small angle to the normal to the mould face. The inclination direction, which may be either downwards or upwards, was towards that *from* which the liquid steel flowed along the mould face. The subject is discussed from the standpoint of the effect of metal flow upon the isothermals near the mould. The length of the columnar crystals was less the greater the turbulence during casting.

(8) The inherent grain size as determined by the McQuaid-Ehn test did not appear to be affected by the method of casting or by the primary structure.

(9) The mechanical properties of samples cut from the chill-cast ingots were more affected by the position in the ingot from which the test-pieces were cut than by the particular ingot. The properties of the sand-cast ingot were somewhat inferior.

(10) There is reason to believe that under completely non-turbulent conditions of casting,

(*Continued at foot of column three.*)

Italian Iron and Steel Industry

According to a report from a direct Axis source, steel production in Italy has been declining since July last, following the entrance of Italy into the war and the restrictions placed on the use of iron and steel scrap which then became necessary with the cutting-off of all further overseas supplies by the blockade. Scrap stocks were fairly substantial about the middle of 1940, but were very soon drawn upon heavily by the steel industry for consumption purposes. Subsequent restrictions in scrap consumption seem to have preserved stocks, which even showed a slight increase towards the end of the year. The resulting deficit in steel production was made good by the importation of heavy tonnages of steel semis from Germany, so that the total tonnage at the disposal of consumers was practically the same as in 1939. The distribution of finished products continues to be determined by a strict priority list, military requirements taking precedence. The output of rolled products declined slightly during the year with the smaller steel supply, but a recovery is expected without having to increase imports to cover the demand.

The Italian government has again given close attention to the production and consumption of pig-iron, to reduce further the reliance on scrap. Electric furnaces have been run during the winter, when usually the majority has been idle owing to water-power shortage. Total pig-iron production during the second half of 1940 was greater than in 1939.

The future of the iron and steel industry "in the peace period after the victory" (*sic*) was discussed at a meeting of iron and steel industrialists last autumn. To meet normal home demand and to maintain an adequate export trade in iron and steel, it was considered essential to expand as quickly as possible the steel-ingot capacity of the industry to between 8 and 9 million tons and the capacity of finishing and fabricating equipment to 10 million tons per annum. In conformity with recent decrees and economic laws, every effort is to be made to increase the output from electrical furnaces and to obtain a better balance between the use of molten and solid charges. Greater use is also to be made of iron sands, as well as the output of special steels expanded. Production costs are a burden and must be reduced; a careful study is to be made of the costs of raw materials and of the most economical utilisation of all plant. Special measures are to be taken for the training of skilled labour and of technicians, as well as more comprehensive and supervised research undertaken.

At the end of November, German and Italian industrialists met at Milan to discuss various problems common to the two Axis partners. A paramount question is the future supply of ore, scrap, pig-iron and coal to the Italian iron and steel industry, indicating the seriousness of the raw-material situation in the light of war conditions, and also closer collaboration between the two industries on the productive side. Complete identity of interests between the two industries was naturally also expressed.

Prices of iron and steel products were officially fixed on the entry of Italy into the war and under decree these remained in force up to March 31 last. No alterations in rates were made in the intervening period, but it is expected that increases will be shown by the new price schedules.

Crucible Swelling Test

The crucible swelling test for coal and its adaptability to New South Wales coals are discussed by W. J. Leslie and J. F. L. Davies in Fuel Research Paper No. 2 of the New South Wales Department of Mines.

Thin-Section Casting Losses

By M. L. Carl, Sloss-Sheffield Steel & Iron Company.

Thin-sectioned grey iron castings may find their way to the foundry scrap heap through a variety of causes. Two definite cases of casting losses have been encountered recently that were directly traceable to moulding sand contaminations.

Sufficient quantities of salt in a sand heap will cause thin-section castings made in such sand to exhibit a vicious type of rust which repeatedly reappears after the casting has been cleaned. The casting surface seems to be pitted deeper than is the case with ordinary rust, and the rust appears in splotches not necessarily covering the entire casting; in fact, less rust is generally found on the heavier sections of the casting. Where a dust-on facing is used on the mould, such rust will appear at the edge of the areas where the sand has peeled off the casting, if allowed to stay in the humid atmosphere of the foundry overnight before cleaning.

Further, the rusty area takes on a purple cast, making one immediately wonder if the dust-on facing might not be responsible, since the rust will appear where the facing has prevented the sand from burning on to the casting. In one case, salt was found mixed with the dust-on facing in one bag of facing, naturally making it appear that the facing was responsible for the trouble, although samples taken from the barrel of facing showed no traces of salt.

The reappearance of rust after air or airless blast-cleaning was noted to take place more quickly than where cleaned by rumbling, since there remains after tumbling a film of dry, powdery sand on the surface of the casting, to prevent its rusting for a short time. In the case of air-blasting, it would be easy to imagine that there was moisture in the blast causing the rust, when in reality the salt in the sand is to blame.

Sulphur in the moulding sand is another, but less frequent, cause of trouble. Fortunately, most moulding sand producers are careful to see that their sand is shipped uncontaminated and in clean goods wagons, but if lump sulphur accidentally gets in the moulding sand, there is always the possibility of some of it coming in contact with the casting surface.

Such contact, it has been found, causes the casting to have a small indentation, $\frac{1}{8}$ in. to $\frac{1}{4}$ in. in diameter, and of a darker colour than the surrounding iron. In some cases, such a pit might not be objectionable, whereas in others it would be enough to cause rejection of the casting.

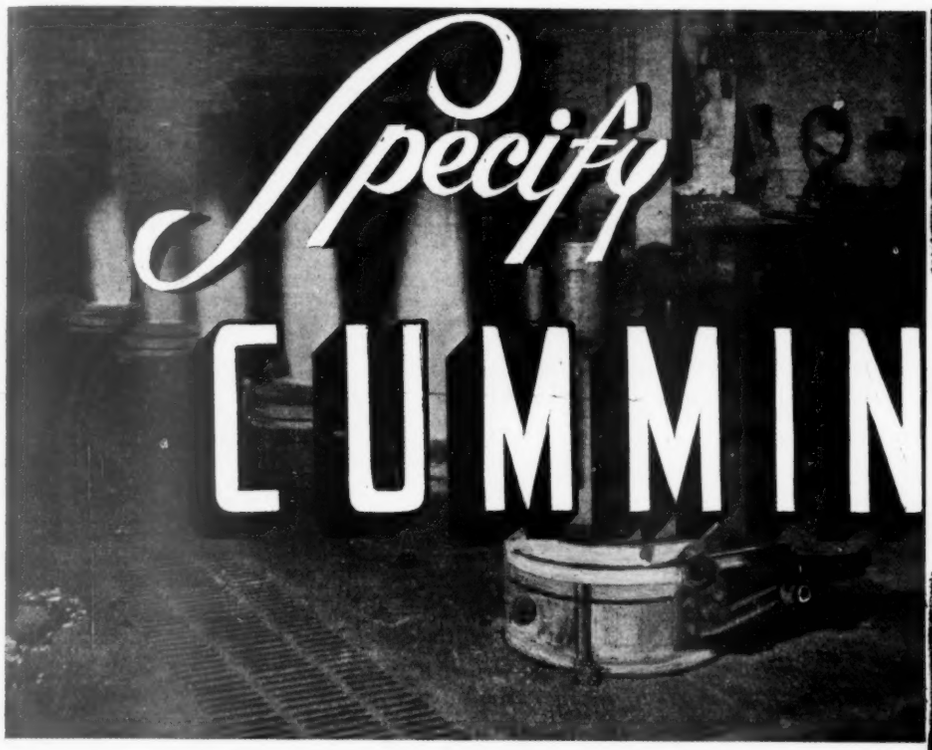
If sand be suspected of containing salt, it may be very easily checked by a chemist. Sulphur may be missed, however, in taking a small sample, but it can be seen by carefully examining the sand when it is practically dry.—From "Metals and Alloys."

(*Continued from column one.*)

the primary structure of the ingots would have been almost wholly columnar.

(11) The distribution of the carbon and other elements is influenced by the method of casting, in particular by those processes making use of a non-axial stream.

Explanations have been put forward for certain of the ingot structures observed based upon the influence of turbulence, concentration gradients and distribution of temperature, and the mode of steel ingot solidification has been discussed.



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The Week's News in Brief

Trade Talk

The Indian Iron & Steel Company, Limited, has declared an interim dividend of 12 annas (7½ per cent.) per share, free of Indian income tax, for the year ending March 31, 1941. This rate is the same as a year ago.

Last Friday, Mr. A. E. McCrea Smith, M.A., addressed the Keighley Association of Engineers on the subject of "Melting and Casting Problems in the Production of High Strength and Special Duty Alloy Cast Irons."

The Board of Trade announce that the address of the Import Licensing Department, on and after April 1, and the Machinery Licences Division of the Industrial Supplies Department, on and after April 3, will be 1-6, Tavistock Square, London, W.C.1.

A new company registered this week in Scotland is Sharp & Company (Lennox Foundry), Limited, of which Mr. Richard J. Rankin, a prominent Dumbartonshire iron and brass founder, is a director. This company has been formed to carry on the business of Sharp & Company, ironfounders and brassfounders, of the Lennox Foundry, Alexandria, Dumbartonshire.

It had now been decided to launch the National Fixed and Demolition Scrap Survey in the whole of the remaining sections of the country not previously covered. The counties concerned are:—Cornwall, Devon, Dorset, Wilts, Hereford, Herts, Bedford, Northants, Hampshire, Surrey, Sussex, Kent, Bucks, Berks, Oxford, Gloucester, Worcester, Warwick, Norfolk, Essex, Suffolk and Cambridge.

Of considerable interest to the light-castings industry is the announcement that the aluminium industry is planning to market after the war a new type of electric fire, consisting of a spherical aluminium basket carrying a centrally disposed heating element. A plastic handle at the top serves for moving the fire which stands about 2 ft. high and eighteen inches in diameter. Naturally it weighs but little.

A short time ago it was announced that the Government had decided to set up a central control of factory and storage premises through which the requirements of all Government departments would be co-ordinated. The President of the Board of Trade has now appointed Sir Cecil Weir to be Controller-General of Factory and Storage Premises. Sir Cecil Weir, who is a member of the Industrial and Export Council, will take up his duties shortly.

Mr. J. F. Davies, the deputy chairman of Radiation, Limited, speaking at the annual meeting of the company held in London last week, said that there were now over two million Regulo New World gas cookers in everyday use. To-day, consequent upon the Factory Act (Canteen) Order, 1940, there was a considerable and growing demand for larger cooking equipment for those smaller factories, which so far had not made special cooking provision for the convenience of their workpeople.

According to the American Iron and Steel Institute, construction of 21 new electric furnaces has been nearly completed; all are expected to be in production early this year. Total capacity of the added electric furnaces is estimated to be at least 900,000 net tons of steel ingots per year. Addition of the new electric furnaces will increase by nearly 50 per cent. the industry's electric furnace capacity. Approximately 1,300,000 tons of additional capacity for producing open hearth steel will be added as a result of the programmes now under way. At the start of this year the electric capacity was about 1,882,000 net tons. The U.S. steel industry has been steadily expanding its electric furnace capacity over a period of years as the result of increasing demand for high-grade steels. This demand has been accelerated by the defence programme's need for greater production of aircraft engines, light armour plate, gun parts, and other types of products in which electric furnace steels are preferred.

Steel capacity in the United States is sufficient to fill all requirements during the next three years if buying is maintained in an orderly fashion, considers Mr. Charles R. Hook, president, American Rolling Mill Company. The United States has a present annual steel capacity of about 83,000,000 tons which will be increased during 1941. Domestic defence needs in 1942, the peak year for such requirements, will not be more than 6,000,000 tons, it is estimated; total British demand including Canada may not surpass 10,000,000 tons, according to present forecasts, and export demand from foreign neutral nations will not exceed 2,500,000, thus indicating a total of 18,500,000 tons for all armament and export requirements. These figures would leave a net available output of 64,000,000 tons for normal domestic requirements which, Mr. Hook declared, exceeds by 4,000,000 tons the domestic peace-time needs in 1929. He pointed out further that the steel industry's capacity is ten times greater than the domestic defence requirements, and more than five times greater than the combined domestic and British armaments requirements.

Personal

Sir Walter Benton Jones has joined the board of Stewarts and Lloyds, Limited.

Mr. Neville Rollason, a director of the United Steel Companies, Limited, has been appointed managing director in succession to the late Mr. Charles J. Walsh. Mr. Richard Summers and Mr. Alan Macdiarmid have joined the board.

Mr. E. C. Teague, for many years works manager of British Timken, Limited, the Birmingham bearing makers, has retired. He has been 27 years with the Timken organisation. Mr. D. McNicoll, who has been appointed works manager, was for some time export sales manager. Mr. C. R. D. Tuckey, recently appointed chief of the planning department, has now been appointed to the position of assistant works manager.

Mr. Herbert S. Simpson, who has been nominated for the Presidency of the American Foundrymen's Association, has been connected with the foundry and foundry equipment industry for many years, both through his own efforts and the experience of his father, Mr. Peter L. Simpson, who, before his death in 1917, had spent his life in the foundry and machinery business. Mr. Simpson was born in Minneapolis and moved to Chicago when a boy. After finishing his education, he engaged in the manufacture of clay working machinery, later becoming assistant to the president of the Hadfield-Penfield Steel Company, Bucyrus, O. In 1917, he left that company to associate himself with the National Engineering Company, Chicago, manufacturers of sand mixing and conditioning and other foundry equipment, of which organisation he has been president since its incorporation. Mr. Simpson is a past-president of the Foundry Equipment Manufacturers' Association. For many years, he has supported the various research activities of the American Foundrymen's Association. He is also a past-president of the Kiwanis Club of Chicago; a former alderman in the city of Evanston, Ill., acting as chairman of the Finance Committee of that body from 1931 to 1934. He is at present a trustee of the Evanston Library Board. The well-known Simpson mixer, manufactured in this country by Augusts, Limited, is one of the new president's inventions.

Will

Robinson, C. H., of Thornliebank, a director and formerly general manager of the North British Locomotive Company, Limited ...	£13,380

Obituary

Mr. Albert Orlando Peech, a past-president of the British Iron and Steel Federation, and from 1920 to 1928 chairman of the United Steel Companies, Limited, died at Leamington recently, aged 68. Mr. Peech was associated with the late Mr. Henry Steel in the formation of the United Steel Companies, Limited, and at the time was one of the proprietors of the family steel business of Steel, Peech & Tozer, Limited, the Ickles, Rotherham, which became the parent of the United Steel Companies. He was chairman of the Templeborough Rolling Mills, Limited, and a director of Owen & Dyson, Limited, Davy & United Engineering Company, Limited, the Appleby-Frodingham Steel Company, Limited. Tinsley Wire Industries, Limited, and other iron and steel companies.

Company Meetings

British Aluminium Company, Limited

Reporting capacity working at the annual meeting of the British Aluminium Company, Limited, held at Shrewsbury on Friday last, Mr. C. W. Cooper (chairman) said that the whole of their efforts were being devoted towards fulfilling Government requirements. All their establishments were operating to the fullest possible extent, and considerable additions had been, and were being, provided in a number of different directions. In the early days of the company, when the output of aluminium was very small, it was a problem to find an outlet for the metal, but they had faith in its future, and as a result, had gradually built up a large and new industry in the country, all the products of which were now essential for munitions of war.

Hadfields, Limited

At the annual meeting of Hadfields, Limited, held last Monday, Mr. P. B. Brown (chairman and managing director) referred to the great loss the company had sustained by the death of Sir Robert Hadfield. They had lost also two of their local directors, Mr. W. E. Parker and Mr. Arthur Johnson. The chairman said they had been favoured within the last few months by visits from the First Lord of the Admiralty, Mr. A. V. Alexander, and from the Minister of Labour, Mr. Ernest Bevin. They expressed on behalf of the Government their appreciation and thanks for the important work that was being carried out by the company.

Federated Foundries, Limited

Presiding at the annual meeting of Federated Foundries, Limited, Mr. William Rennie (chairman) said that 1940 had been a most difficult year for the light castings industry. Their efforts had not so far resulted in the full use of the available resources of the company in wartime production, though they had done everything in their power to obtain work to replace that lost through the cessation of house-building.

Reports and Dividends

Stewarts and Lloyds, Limited—Dividend of 12½ per cent. for 1940 on the deferred capital (same).

A. Reyrolle & Company, Limited—Final dividend of 7½ per cent., making 12½ per cent. (same) for 1940.

John Hetherington (Holdings), Limited—No dividend on the 7 per cent. cumulative preference shares for the half-year to March 31, 1941.

Switchgear & Cowans, Limited—Net profit, £14,985 (£10,295); ordinary dividend of 15 per cent. (10 per cent.); carried forward, £6,479 (£5,844).

British Oxygen Company, Limited—Final ordinary dividend of 8 per cent., making 15 per cent. for 1940 (for the previous year the total distribution was 17 per cent. and a capital bonus of 20 per cent.).

Manganese Bronze & Brass Company, Limited—Net profit for 1940 (before reserving £78,000 for E.P.T.), £146,856, against £88,824 (after reserving £16,500 for E.P.T. and N.D.C.) in 1939. Ordinary dividend of 25 per cent. on the capital increased by last year's scrip bonus.

Parker, Winder & Achurch, Limited—Profit for 1940, after writing off depreciation and providing for income-tax, N.D.C. and E.P.T., £18,852 (compared with £20,516); brought in, £17,430; dividend on the ordinary shares of 10 per cent. (same), and a bonus of 2½ per cent. (same); to reserve (making it £80,000), £10,000; carried forward, after preference dividend, £19,702.

Gibbons (Dudley), Limited—Net profit for 1940, after providing for taxation and depreciation, £24,835; brought in, £15,019; 7 per cent. preference dividend (free of tax), £2,100; dividend of 10 per cent. on the ordinary shares, £7,690; bonus of 2½ per cent., £1,923; A.R.P. expenses, £5,000; dividend equalisation fund, £2,500; to reserve, £5,000; carried forward, £14,741.

Hadfields, Limited—Trading profit for 1940, £297,316; debenture interest, etc., £37,695; net profit, £259,621 (£264,298 in 1939); brought in, £475,802; preference dividend, £7,762; interim dividend of 7½ per cent. on ordinary stock, £46,498; final dividend of 1s. 6d. per unit of 10s. (15 per cent.), making 22½ per cent. for the year (same), £92,996; carried forward, £588,167.

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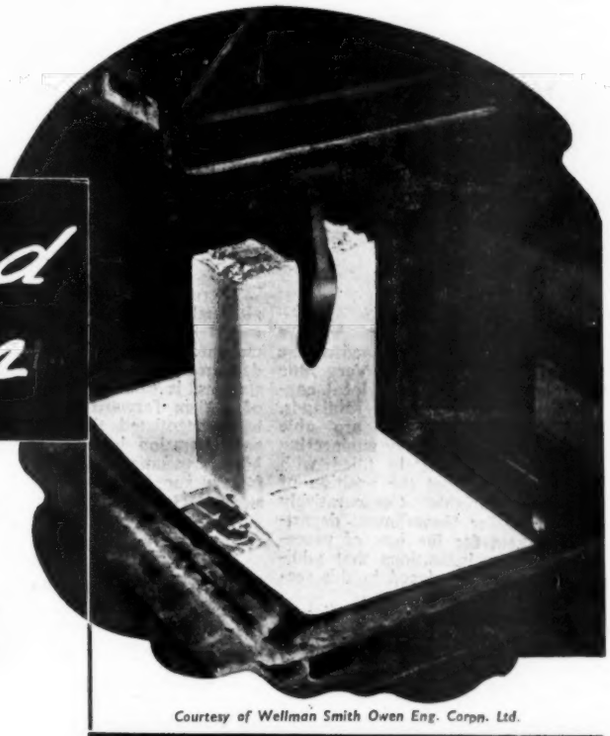

Courtesy of Wellman Smith Owen Eng. Corpn. Ltd.

follows use of PLASTIC K-N

THE elimination of joints, a refractory surface possessing non-shattering properties able to withstand mechanical impact and abrasion without rupture or disintegration, a furnace bottom chemically neutral in its resistance to slag, whether acid or basic, and a high degree of refractoriness. These are some of the advantages which follow the use of Plastic K-N. An improved chromite composition, Plastic K-N when rammed into position forms a strong and durable hearth. Its unique slag and shock resisting properties ensure uninterrupted production, as well as cleaner ingots, forgings, sheets or plates.

Full details are available on request.

Some advantages obtained by use of Plastic K-N

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Resists slag action, holds heat and promotes uniform heating of stock. Withstands severe abrasion and mechanical shock. Eliminates "pick up" from refractory materials.

SOAKING PITS (Hearth and Bridge Walls)
Slag and abrasion resisting surface together with non-shattering properties.

ELECTRIC BASIC FURNACES (Sub-Hearth)
Under dolomite or magnesite hearth; minimises possibility of a break-through.

WATER TUBE BOILERS (Black Liquor Fired)
As a refractory fill between tubes of water walls, also for hearths and coping of bridge walls. Resists the corrosive action of liquor and gases.

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CEMENTS: *Sintex, Durax, Pyrolyte.* PLASTICS: *Durax, Rotaline. Plastic K-N., Glendoline, Ground Ganister, Steel Moulders' Compositions.* SILLIMANITE: Tank Blocks, Bricks and Cements. SANDS: Moulding, Brick Facing, Silica, Glass.

Raw Material Markets

Workers in the iron and steel industries will be given a short break at Easter, but present circumstances do not permit of an extended stoppage of production. In addition to employees having a well-earned rest, the opportunity will be taken to carry out renovations of plant; the latter procedure, however, is less the cause of a cessation of working at the factories nowadays than was the case in peacetime, repairs being attended to whilst the plant continues to run, as far as possible. Heavy foundries continue to be fully employed on essential contracts, while slightly more official work is being placed with the light foundry trade, although not yet in sufficient volume to facilitate full-scale outputs.

Pig-Iron

MIDDLESBROUGH—Blast furnaces in the Cleveland area continue to be fully engaged on the production of iron for the steelworks. Very little foundry iron is being turned out here, local consumers acquiring their needs from the Midlands. Fortunately, makers in that district are able to meet all demands promptly. Heavy engineering concerns' order-books are completely filled with work of national importance, but the position of makers of light castings is variable. Comparatively few have sufficient work for Government departments to compensate them for the loss of peacetime outlets, but there are indications that additional official contracts may be placed in this section in the near future.

While there is a ready disposal of all supplies of hematite which become available, there is slightly less tightness in the market, as many users have altered their mixtures in order to utilise more freely grades of iron which are rather more easily obtained. Fairly substantial tonnages of imported hematite have been distributed by the Control to make up the deficiency in home production, and every effort has been made to adapt mixtures so that minimum quantities of hematite are involved. Costs of production of hematite have advanced of late, and there have been suggestions that prices may be advanced, but so far nothing has been done in this respect, contracts for supplies to be delivered during the second quarter of the year being on the basis of 138s. 6d. per ton, less 5s. rebate, for No. 1 hematite to consumers on the North-East Coast and in Scotland, 144s. in Sheffield, and 150s. in Birmingham.

LANCASHIRE—In the aggregate, demand for foundry iron from consumers in this area is on an extensive scale, speciality engineers, including machine-tool makers and heavy electrical concerns, being the largest users. The requirements of the light-castings trade are not substantial, as many works in this branch are unable to operate their plant to capacity, while jobbing foundries, too, are unfavourably situated in many instances. Generally speaking, ironmakers in the Midlands are despatching adequate supplies to consuming points in Lancashire, but not all producers can deal with inquiries promptly, owing to the necessity for placing a proportion of their furnace capacity on the manufacture of basic iron.

MIDLANDS—Consumption of high-phosphorus iron remains steady, with a tendency towards expansion, as larger tonnages are being taken up by the heavy engineering trade, many works using this type of iron as a substitute for better quality irons which are less easily obtained. Derbyshire and Northamptonshire makers are generally able to give quick delivery, however, and the supply situation is particularly satisfactory in the latter district. The position of the light-castings industry changes little from week to week, but, although the normal trade of this branch must inevitably remain unsatisfactory, makers are receiving a bigger volume of work for Government departments. Heavy engineers, of course, are fully booked with priority business, and the high rate of operations is reflected in the demand for low-phosphorus iron and hematite, together with increasing specifications for refined irons.

SCOTLAND—While manufacturers of heavy castings continue to be very briskly employed on all types of work of national importance, activity in the Falkirk and district light-castings trade is still only moderate, and much more business could readily be dealt with if it were available. At present it does not seem as if this will be forthcoming for some time to come, as the move to get these works employed on Government contracts is not making the hoped-for progress. Pig-iron deliveries to the heavy engineers are sufficient to obviate lost time, but the current rate of despatches of iron does not facilitate the stocking of any material, users having to operate on a hand-to-mouth basis. Basic iron is coming to hand quite freely, but hematite is rather difficult to obtain, deliveries being confined to priority consumers.

Coke

There is still no change in foundry coke prices, although it had been expected that the Control would have sanctioned an increase by now. The current quotation for Durham best foundry fuel, delivered to Birmingham and Black Country stations, is 61s. 6d. per ton. Despite the absence of a firm forward price, long-term contracts are being negotiated, the makers being covered against any alteration in prices by a rise-and-fall clause. Many consumers are taking advantage of the satisfactory supply situation to build up useful reserve stocks.

Steel

Distribution of both home and foreign iron in this country is in the hands of the Control authorities, and there is very little metal allocated to other than consumers engaged on work connected with the war machine, so pressing are the demands of these users. Production in the United Kingdom is at a very gratifying level, but the need for importing supplies cannot be overcome. In addition to heavy demands on the output of ordinary qualities of steel, there is an ever-increasing call for special grades for armament and other war purposes.

Scrap

Consequent upon intensified efforts to bring out supplies of iron and steel scrap required for essential purposes, larger tonnages have recently become available, and delivered where the need is most urgent, but still there remains a considerable number of users eagerly awaiting delivery of larger supplies than are at present forthcoming. The national scrap survey is making rapid progress, and no known potential sources of supply are being allowed to be overlooked, as the need for utilising all home-produced scrap is appreciated. Imported material is readily to hand when necessary, but shipments are naturally restricted as much as possible.

Metals

The London Metal Exchange will be closed from Thursday afternoon until Tuesday morning for the Easter recess.

Tin—Following heavy sales in the East, lower prices have been quoted there, and this easier tendency has been reflected on the London tin market, although quite good sales have been negotiated. It is believed that some of the buying of cash tin represented deferred covering against the recent granting of export licences for April. Tenders for a United States Navy order of 450 tons for shipment from the East were completed on Thursday last; it is understood that two-thirds was secured by Dutch interests and the remainder by the American Metals Reserve Company. It is announced that regular shipments of Bolivian ore to Texas City are to begin shortly, indicating that no time is to be lost in the construction of the American tin smelter.

The total visible supply of tin on March 31 was 35,252 tons, according to Mr. W. H. Gartsen (Henry Rogers, Sons & Company), as compared with 38,308 tons at the end of the previous month. The carry-over in the Straits Settlements was 2,209 (3,165) tons, while the carry-over at principal European smelters was 2,946 (2,939) tons. American tin deliveries in March reached the record level of 16,092 tons, the previous highest level being 12,760 tons in January last. The large-scale deliveries during March may be attributed to stock accumulations by the Metals Reserve Company. United Kingdom deliveries increased from 926 tons in February to 1,116 tons in March, but for other countries declined from 2,130 tons to 1,641 tons; total deliveries were thus 18,849 tons in March, compared with 15,251 tons in February.

World production of tin in February is estimated at 17,800 tons, compared with 17,400 tons in January, according to the Statistical Bulletin of the Tin Research Institute. Production for the first two months was 35,200 tons in 1941, against 30,800 tons in 1940. United States deliveries totalled 12,195 tons in February, against 12,760 tons in January. The U.S. deliveries for the first two months of 1941 were 24,955 tons, compared with 16,380 tons in the corresponding period of 1940. Tin consumption in the United Kingdom was 2,672 tons in January, against 2,198 tons in December and 2,620 tons in January, 1940. World stocks of tin, including smelters' stocks and carry-over, decreased by 2,103 tons during February to 57,703 tons at the end of the month. Stocks at the end of February, 1940, were 47,525 tons.

Tin prices on the London Metal Exchange during the past week have been as follow:—

Cash—Thursday, £267 15s. to £268; Friday, £268 10s. to £268 15s.; Monday, £269 to £269 5s.; Tuesday, £268 10s. to £269.

Three Months—Thursday, £265 5s. to £265 10s.; Friday, £266 10s. to £267; Monday, £266 15s. to £267; Tuesday, £265 15s. to £266.

Copper—Consumption of copper by non-essential users may be expected to decline steadily as a result of the Government's policy of reducing production of articles for civilian use to a minimum. On the other hand, priority requirements of the red metal are steadily rising. There is a plentiful supply of copper to satisfy all urgent demands, but none is to spare to meet the needs of other users, as it is the policy of the Control authorities to conserve the metal for the use of war contractors. There is a brisk domestic demand in the United States, and primary producers continue to quote 12 cents per lb., delivered Connecticut Valley, for electro. On export account the current price is around 10.50 cents, f.a.s. New York, but business is very quiet.

Spelter—Non-essential users of this metal are experiencing ever-increasing difficulty in obtaining supplies, owing to the increasing demands by priority concerns and the advisability of regulating distribution carefully. Official encouragement is being given to the use, where possible, of substitutes and processes not incurring the consumption of zinc.

Lead—Cable and battery manufacturers continue to take up considerable tonnages of lead for use in Government contracts, but ample supplies are available. The call for lead from pipe and sheet makers is comparatively dull compared with peacetime standards. On the whole, the supply situation is quite satisfactory, permitting, as it does, reasonable tonnages to be distributed among non-essential buyers.

Contracts Open

Cymmer, April 19—About 50 tons of 6-in. spigot and socket cast-iron pipes, etc., for the Glyncorrwg Urban District Council. Mr. H. Walsh, engineer and surveyor, Council Offices, Cymmer, near Port Talbot, Glam. (Fee £1, returnable.)

Naas, April 18—Supply and installation of two electrically-driven centrifugal pumps, for the Kildare Board of Health and Public Assistance. Mr. N. O'Dwyer, consulting engineer, 6, Burlington Road, Dublin. (Fee £2 2s., returnable.)

Ossett, April 21—Provision and erection of electrically-driven pumping plant, for the Corporation. The Borough Surveyor, Town Hall, Ossett, Yorks. (Fee £2 2s., returnable.)

Pretoria, April 30—Supply and erection of circulating water pumps and pump-house equipment, for the City Council. Merz & McLellan, consulting engineers, 32, Victoria Street, London, S.W.1. (Fee £5 5s., returnable.)

Saltash, April 16—Construction and maintenance of about 2 miles of 4-in. spun-iron and steel water mains, for the South-East Cornwall Water Board. Lemon & Blizard, engineers, 24, Lockyer Street, Plymouth. (Fee £3 3s., returnable.)